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Mind-Set and Learning[1]

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"Are we ready to continue our discussion, and shall we begin where we left off?" "Please, before you go further, give a short summary of what was said last time. Several of us here today were not present then, but have been attracted by the reports that have gone out. Give us the gist of your discussion."

"We covered a good deal of ground, but I'll try to sum it up. We agreed that teachers should study the psychology of learning for the double reason that with it they could teach better and that understanding better how learning goes on, they would get more satisfaction from their teaching. The symbol S—R opens, as it were, the door to the psychology of the learning process. Any act of conduct consists of some sort of response (R) to some stimulating situation (S), as I hear a shout (S) and turn to listen (R). All conduct can be so described. The symbol is best conceived in terms of physiological psychology: the stimulation (S) takes place because in the nervous system there are mechanisms, so to speak, especially suited to receiving such stimulation; and other mechanisms appropriate for responding. Any particular response (R) follows appropriately a certain stimulus (S), because there is also in the nervous system a specific nerve structure path or bond (neurones and synapses, to be more specific) connecting the initial sensory mechanism with the final motor response. These paths or bonds may be thought of somewhat as the systems of wires connecting different telephone instruments. Talking at one end corresponds to the stimulus, hearing at the other end to the response. My friend hears me talk because at my

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request the various switchboard operators have appropriately joined the intervening wires. Now in the case of the human telephone exchange systems—our whole aggregate of nerve structure—we bring into the world with us at birth some of the connections between S and R already made, as when a missle flies close to the eye (S), the eyelid closes (R). Other connections we make only after (certain kinds of) exercise; as I may, after learning, strike a baseball (R) when I see it coming (S). This making new connections between S and R (or changing old ones) is what we mean by learning.

"One very interesting fact was noted about the action of the mechanisms that have to do with receiving and conducting stimulations and with making responses: at some times these mechanisms are more ready to act than at others. Repeated exercise may result in fatigue and the mechanism may then fail to respond to a stimulus that would in the beginning have sufficed to bring a prompt response. Certain mental attitudes also will cause readiness or unreadiness. If I am very angry with a man, I am unready to laugh with him, but I am—alas—only too ready to hear evil of him. If I am very anxious to succeed at golf, I am easily brought to think about golf strokes, golf clubs, golf records, and the like. This fact of mind-set needs to be distinguished from simple readiness. Suppose I, being thus interested in golf, am entering eagerly upon a tournament with high hopes of success. In such case my mind is said to be *set* on the end of playing to win. If anything postpones the start I am restless: my mind-set acting within urges me on. Such a mind-set radiates, as it were, a wave of readiness to all my conduct mechanisms that are likely to be needed in my play. And just as truly the same set radiates unreadiness for any thwarting activities. My mind-set thus contemplates some end, urges me from within to put forth efforts to attain this end, makes ready for action my various mental and physical resources that may be used in action, and at the same time makes unready for action any mechanism that might by its action interfere with attaining my end. The value of the mind-set in making thus for effective effort is, as we shall presently see, no greater than its value in making for effective learning.

"The laws of learning are concise statements of the conditions under which learning takes place. Everything so far is in a way preparatory to them. Thorndike recognizes three principal laws of learning, those of Readiness, Exercise (Use and Disuse), and Effect (Satisfaction and Annoyance). The law of Readiness connects the fact of readiness as described above with the facts of satisfaction and annoyance: *When a bond is ready to act, to act gives satisfaction and not to act gives annoyance. When a bond is not ready to act, to be forced to act gives annoyance.* The especial significance of this is to be seen in its connection with the law of Effect (Satisfaction and Annoyance): *A modifiable bond is strengthened or weakened according as satisfaction or annoyance attends its exercise.* It follows at once that learning (strengthening a desired bond) will take place more easily if the bond is in a high state of readiness. Indeed if a bond is so unready to act that annoyance attends its exercise, unlearning (or weakening the bond) rather than learning (or strengthening the bond) may be expected."

"Does this explain the value of interest in learning? I have always believed that interest helped learning, but now I seem to see more in it than ever before."

"Exactly so; to take interest in doing anything is to have a mind-set towards it. That means, as we saw, an inner urge to engage in that thing and readiness in sense and thought for whatever helps it along."

"Why say 'readiness in sense'? Do you mean that my eye actually sees things I am interested in better than it sees others? I thought the eye was like a mirror or camera and saw everything in front of it."

"The *eye* does see everything in focus before it, and, as a mere mirror, sees them indifferently; but *you* don't see them that way. *You* pick out from all the things in front of your eye certain ones to pay attention to. When I say 'you pick out,' it would be more exact to say that your mind-set at the time, your various readinesses, pick out the things significant to these readinesses. Don't you know that a girl on her way to buy a hat will see the shop windows of the milliners more certainly, more readily in fact, than the windows of the hardware stores? Her eyes, as bare optical instruments, may see

the hardware windows, but that seeing meets no response within. Actual and effective seeing is selective according to the mind's set at the time. So with hearing and all the rest."

"Then the working of interest is a scientific fact, and not mere sentimentality. I had got the idea that really hard-headed thinking ignores interest. Haven't we been told that?"

"Possibly you have heard something like that, and some sentimentalists have brought just reproach on a good cause. But it is true beyond a doubt that interest is a significant factor in mental life and a positive help to learning."

"It seems, too, that you don't oppose interest to effort. I thought some people hold that you have to choose between interest and effort, that you can't have both."

"You are certainly right that I don't oppose interest to effort. Exactly the contrary: interest is the natural, indeed the only basis of effort; the stronger the interest, the stronger, if need be, will be the effort."

"You gave the law of Effect as if it were scientifically established. Is it not true that some psychologists reject it? It seems to me I've heard about some rats learning a path quicker if they were punished for going wrong than if they were rewarded for going right. What does this say about the effect of satisfaction?"

"There are two replies to be made to that. First, the law of Effect includes, as its statement shows, both satisfaction and annoyance. Whether the rats learned faster by punishment or by reward matters not to this law; either learning was by effect. The fastest learning, other things equal, is where both are used, satisfaction when they go right, annoyance if they go wrong. The other reply is that among psychologists, Watson alone, so far as I have heard, denies the law, and he gets little if any backing in his contention. It is true that some very good psychologists have questioned whether the law as stated is ultimate. They do not deny the law as a fact, they merely propose to explain it by appealing if possible to more fundamental considerations."

"Suppose any one denied the law, could he consistently use punishment?"

"If this law is not true, punishment has no place in the learning process strictly considered. The fear of punishment

might be used to secure practice, and so in this indirect way affect learning, but to be consistent, one who denies this law would have to deny that the pain attached to going wrong helped the rats to learn more quickly the way out."

"I wonder if everyone understands the word satisfaction in the same sense. Do you mean by satisfaction pleasure and by annoyance pain?"

"No. I do not mean to make satisfaction the same thing as pleasure. Sometimes they may be the same thing, more often not. If I had to choose single words as synonyms I'd use success and failure. Indeed Woodworth uses these words instead of satisfaction and annoyance."

"Well, won't you please leave off this hair-splittnig and arguing! If the laws you talk so much about are of any service please go on and explain how we can use them."

"Very well. Take the very specific case of John who has not well learned his number combinations. Suppose he is called on in class for 7 x 9. He hesitates; it might be 72, or 56, or 63. Which is it? He tries them in this order. When he says 72, the teacher looks unimpressed, certain pupils quickly raise their hands, one or two actually snicker, the teacher says 'No.' Now this response of 72 did not bring satisfaction because it did not succeed. He saw by the words and manners of teacher and fellows that 72 was the wrong response. The failure brought annoyance, and the snickers served to increase it. When he ventures 56, he is by reason of the previous attendant annoyances the more anxious to find it right. This very anxiety increases the annoyance of failure. When finally he says 63 and it succeeds, his satisfaction is all the greater by reason of his previous failures and their attendant annoyances. Now the law of effect says that next time he will be less likely than he was this time to say 72 or 56 and more likely to say 63. If this happens often and consistently enough, he will eventually say 63 at once without fail."

"I heard a speaker say that the trouble about some punishment is that it makes a boy regret that he was caught, not regret that he did wrong. Just what did he mean? What difference does it make?"

"The trouble is one of misplaced annoyance and it makes

all the difference. Go back to our law of Effect. If a response is made to a certain situation with annoyance, when that situation comes around again we shall be less disposed to respond in that way. If this keeps up long enough, we simply won't respond at all to that situation with that response is the boy annoyed, at having done wrong or at get-wrong, is caught at it, and is punished. Here the situation (S) is meeting the temptation, the response (R) is two-fold, doing the wrong and letting himself get caught. The punishment provides annoyance; but with which part of the response is the boy annoyed, at having done wrong or at getting caught? It depends upon the boy and what he thinks. If he regrets (is annoyed at) having done wrong, then he will next time be less likely to repeat the wrong. But if he regrets (is annoyed at) being caught and no more, he will next time take greater pains not to be caught, and no more. The effect of the punishment on his character education depends exactly on the thing at which he feels annoyance, whether on having done wrong, on having got caught, or even (if he is a husky young fellow) at having submitted to being punished. It is all important that satisfaction and annoyance be attached appropriately."

"Well, you've scored on that application of the law of Effect, for that's an important matter."

"Now tell us how a mind-set influences learning? And does readiness come in? And what are the connections between the laws of Readiness and Effect?"

"This is what we have been all the time leading up to. Suppose a girl has asked her mother's permission to make a dress 'all by herself' and her mother has at last consented. What do you say? Any mind-set?"

"I should say so, there is a very definite mind-set. I remember something like this when I was young, and I was nearly wild with enthusiasm and determination. I was bent on showing them all that I could make a dress. I chose a party dress, because I had been invited to go to a more important party than usual and I thought I had no suitable dress. Yes, there is a definite mind-set."

"And what about an inner urge?"

"What do you mean by an inner urge? Is there also an outer urge? And are the two different?

"Let me answer that. I know the difference. Sometimes I find a boy bent and determined to do something, say make an airplane. Then the urge is inside the boy. I may try to discourage him, others may laugh at him, he may find difficulties, but as long as he feels that way inside he will persist in spite of all outside interferences. That's an inner urge. But suppose the boy's father tells him to mow the lawn, and the boy does it only because his father makes him, the urge here is outside. With an outer urge one will let up at the first opportunity. If any interference comes along, he will try to take it as an excuse to stop. This girl had a strong inner urge to make the dress. A strong mind-set to accomplish an end means exactly a strong inner urge. Am I not right?"

"Exactly right. But now tell us what else this girl's strong mind-set means besides an inner urge?"

"You called it further back a mind-set-to-an-end. I should say it means a clear and definite end in view, a strong purpose with a clearly defined end. Here the end was to make a dress that would fit and be becoming, and call forth favorable comments from all who saw it and wonder that so young a girl should make such a success. The strong mind-set means setting up this sort of end."

"And what about readiness or unreadiness?"

"I know; it was just what we had before. The mind-set makes this girl ready to see and examine dresses and styles and patterns and fabrics, and to hear people talk about such matters, and to read *Vogue* and the *Delineator*."

"Yes, it will make ready for action all the mechanisms in the girl's mental makeup that might have to do with making the dress. But what about unreadiness?"

"We had that too. It makes the girl unready to do anything else. I dare say she is more or less of a nuisance about the house till the dress is finished, for she won't want to be called on to mind the baby or to set the table or even to be told it's bed time. Yes, all the mechanisms whose action might interfere will be distinctly unready to act."

"What does all this mean for thinking? Does this girl think?"

"Certainly she thinks. She has to choose the style in which she will make the dress. That takes thinking and a great deal of it. I guess she'll run everybody in the house nearly crazy

looking and passing judgment, unless she is one of the kind who somehow already knows her own mind. Then she has to choose the material, and watch the price so as not to exceed her money. After that it will be the pattern and how to lay it on, how to cut it out, etc., etc. Yes, she has to think."

"An important matter is what guides her thinking? What tells her what to think? It is the end in view that guides. Here it is exactly the kind of dress she wants to make that guides her thinking. In this case it is a party dress. Her purpose to make this party dress guides her thoughts at least in a large way all the time. Some smaller purposes, specific subordinate ends I suppose you would call them, guide at other times; but all have to fit together."

"You say all have to fit together. Is this what some call organization?"

"Exactly, this is what is meant by organization. Everything she does, buying, planning, cutting, sewing, all have to work consistently together or she will not have the kind of dress she wants. I should say there is opportunity here for the best kind of organization. How to organize her efforts is part of what she had to learn, and an important part."

"But are you not leaving out the most important thing, the learning? I can see how the girl's purpose means a definite end in view and an inner urge to attain that end. I can see too how these things mean an efficient organization of effort—in fact the whole thing seems to be working for efficiency of action. But I don't yet see where learning comes in. Can you explain more clearly?"

"All we need is to apply our previous reasoning. Learning mainly comes by the law to Effect. Any movement of mind or body that succeeds (or brings satisfaction) has for that reason a better chance of being used again. Similarly any movement that fails has a smaller chance. This better (or less) chance of being used again we call learning. The greater the feeling of success or failure (satisfaction or annoyance) the more definite the learning.[1] Now if the girl has a strong interest in making the dress, what she does by way of planning or execution that makes manifestly for success brings great satisfaction. Wherein she fails, she feels annoyance. This

1 Except in some extreme cases where such factors as consternation or paralysis of action interfere with the learning process.

success (satisfaction) fixes in her nervous system the success-bringing movements. The annoyance in like manner tends to cut out the failure-bringing movements. When the girl has finished her dress, each step that helped make it a success is more firmly fixed in her (as a habit or skill or memory), and each step that hurt will less likely be used again. And not only are the separate steps thus fixed (or dropped out), but so likewise are the connections of one step with another. The organization as an effective whole is fixed in the girl's mental make-up. The stronger the purpose and the more definite the success (or failure) the stronger and more definite the learning."

"You have said nothing about the factor of readiness here. Does that play any part?"

"Yes, indeed. The readiness we discussed as growing out of the mind-set not only prepares each pertinent mechanism for use but accords satisfaction when used. We then have, as it were, satisfaction coming possibly from two sources, first, from the readiness of the mechanisms used and, second, from the resulting success. This fact means the possibility of better learning."

"How does consciousness help? Does it have any part in the learning process as here described? I have heard some say that this too is an important factor."

"Indeed it is an important factor. Its function here is at least three-fold: first, to connect more surely and definitely the various responses with their several appropriate stimuli, second, to attach satisfactions or annoyances more precisely where they severally belong, and third, by emphatic attention to heighten the satisfaction or annoyance felt. It is for these reasons, among others, that we are most anxious that pupils think while they act and consciously intend the several steps they take."

"I have to admit that you have proved your case. I was skeptical at first. But now I see no escape. If the laws of learning are true, purposeful activity is the way to utilize them. It should make teaching both more effective and more interesting thus to understand the working of educational psychology. Readiness, mind-set, action with satisfaction, these do indeed give a different outlook upon teaching."

Is General Science Destined to go down into the Junior High School? If so, what will be the Content of the Course? [1]

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When one has the task of answering a double question, like the one just read, by a double-horned prophecy, he feels very much like answering the first question in the negative, and thereby avoiding the necessity of answering the second at all. To answer the questions named, in a manner at all adequate, would require an extended consideration of the meaning of the Junior High School and an equally elaborate discussion of the meaning of General Science. The first part of the question means, presumably, this: "If the High School organization and curricula are divided into those of the Junior High School and those of the Senior High School, will General Science be found in the Junior High School? If by the Junior High School we mean the usual seventh, eighth, and ninth years, the answer to the question is undoubtedly: "Yes." I feel quite certain of this answer in spite of the fervid attempts made a few years ago to swing educational public opinion over to a two-year General Science program for the four-year High School. In my judgment this movement has not succeeded, and will not succeed, unless by a two-year program in General Science we mean to include a year of General Science and a year of Biology, each being run half time for two years as a split course. The fact remains that for the three-year Senior High School a year each of some biological subject, of Chemistry, and of Physics are the rule, and will continue to be the rule. The War placed an unusual stress upon the Physical Sciences, especially upon Chemistry; this stress, if there were no other causes, will usually reserve the last two High-School years for these sciences during many decades to come. As a rule, the first year's work of the four-year High School will be some Introductory Science of a general, rather than of a specific character, and the second year's work will be some form of Biology, pure or applied. In the

1 Given at meeting of Central Association of Science and Mathematics teachers in St. Louis, Nov. 25, 1921.

country districts the Biology work will be essentially agricultural in character.

Now as to the content of the General Science course, whether the course be given in the last year of the Junior High School or in the first year of the four-year High School. If one were to believe all he hears, in these strenuous days of controversy, he would conclude that the important thing about General Science at the present time is not its content, not what it may accomplish for the pupil and the community, but the method by which it is to be taught. This is only a part, of course, of the age-long contest as to whether it is better to have something to teach, or to have a method of teaching. Of this dilemma I desire to take neither horn. Everyone knows that some teachers are helped by being compelled to follow some set method of work; it is equally true that many teachers are wrecked, as vital forces in the school and community, by too much methodology. One must choose sometimes, and the choice will depend upon a number of considerations, but chiefly upon the character and aptitudes of the teacher. The important thing is, first, that the pupil shall be interested in Science, that he shall ask questions concerning the world about him, including the community of which he is a part. A second result, of equal importance with the first, is that the pupil shall be in a better position, after studying General Science, to answer his own questions, or, at any rate, to know, in a small way, to what source he can go for the answer. Some teachers can accomplish this result by one method, some by another. The tragedy of General Science, as it is for all Science, is that in too many cases the subject must be taught by teachers who are not really interested in Science at all, or no more interested in Science than in any other subject of the curriculum. For these no method is of much value.

The object of General Science instruction is, as has been stated, the interesting of the pupil in his world and its phenomena. It is desirable for the pupil to have this interest in order that he may realize how dependent he is upon natural law, and how much the knowledge of the laws of nature will benefit him in his life work and as a member of the community. This interest should carry him into some of the special sciences. It is the fashion in some General Science quarters to decry the relation of General Science to the later, special

sciences. Let the course be sufficient unto itself, is the demand. To a certain extent it is true, of course, that the topics in General Science need not be selected as if the course were merely a preparation for the work of some subsequent year. But in a larger sense the course *is* a preparation, and should be held accountable for having accomplished something more or less tangible. It is far from the idea of those who pioneered in Introductory Science to ask nothing from the course but a study in methods. If the pupil leaves the educational system at the close of the ninth year, he should have the rudiments, at least, of the great, general scientific ideas. This is what General Science will mean to him. If the pupil continues his work into the later years of the High School, or into the Senior High School, the course should have shown him the importance of Science, and should predispose him to the election of Biology, Physics, or Chemistry, to say nothing of some of the other sciences, such as Physiography, Geology, or Zoology. In a large sense General Science is a preparation, and cannot be treated as though it were sufficient unto itself.

What is true of General Science in the four-year High School is true, *mutatis mutandis*, in the Junior High School, if the educational system provides this latest subdivision of High School organization. The organization of Junior High Schools, no matter what transcendent reasons may be found for them at this day, was primarily an economic one. Instead of building a new High School whenever the growing High School population burst out of its too-small quarters, it was the habit for many years to rent old houses or apartments in the neighborhood, and there to house the greater part, if not the whole, of the first-year High School class. This policy, like all temporary expedients, finally reached its limit here and there, and the public decided to tax itself for a new building. But what sort of a building? In our large centers of population, with the great increase of family means, and the constant effort on the part of the school authorities to stimulate attendance by the introduction of Commercial, Home Economics, Industrial, and similar courses, the race between school population and school rooms has been an unending one, with the result never in doubt. The new building was built for the overflow, which was the first-year class; then, as the upper grades were also crowded, some of the seventh and eighth grade pupils were

sent over to the Junior, or Intermediate, High School building. When this synthesis of the seventh, eighth, and ninth years had been accomplished in a few places, schoolmen saw the opportunity presented, and the question of a unified curriculum for these grades became one of living interest. The end is not yet. As newer reasons for the formation of Junior High Schools, we have the following:—

(1) They are a device for holding pupils in the school system during years of great student mortality, and of carrying these students over into the Senior High School, or, at any rate, of keeping them in school for one additional year.

(2) In the Junior High School provision can be made for instruction hitherto very difficult or nearly impossible, in the grade schools. Included in this type of instruction is laboratory work in Science, Household Science, and the Manual Arts. The laboratory facilities provided need not be as elaborate as if they were in the four-year High School, with its more formal science courses.

(3) The teachers of the Junior High School may be upon a lower salary scale than if they were in the four-year High School. This follows from the fact that teachers of essentially seventh and eighth grade training may be employed instead of the college graduate now demanded by the best High Schools. This question came to College Entrance Committees in an acute form, some years ago, when they were confronted with algebra courses which were presented for college entrance, and which had to be considered as a preparation for College Algebra, but had been taken in the eighth grade of the grammar school, along with the Three R's.

(4) As a fourth reason for the Junior High School we have the argument that in such an organization the special-subject teacher can ultimately be employed in the place of the room teacher. This argument has already been stated in another form.

Without going farther into the history of the Junior High School or similar types of organization, let us consider what the General Science course of such a school should be. The question assigned me includes this; but from a prophecy of the future I insist that I must be excused. I will content myself with a place among fallible mortals, and state only what I think the Science course *should* be. Part of what the course

in General Science should be has emerged from the discussion that has already been presented.

(1) The course should have an experimental basis. This is true whether the instruction is by the Project Method, so called, or by the usual Deducto-Inductive method.

(2) The course should require study, reading, and recitation, with some small residue left at the end of the semester or year as an increment of the student's knowledge.

(3) Th course in General Science should lead the student to inquire regarding phenomena and the common practices of his community, and to make a beginning, at least, of distinguishing causes from their effects.

(3) The course in General Science should lead the student to desire to study some of the special sciences of the later years.

First, as to the experimental basis of Introductory Science. The best way, in my opinion, is to have the pupil carry on experimental work for himself. This work need not be as ambitious, by a great deal, as the laboratory courses of the Senior High School, but they should encourage the pupil to see that real experimentation is not a matter of flasks and beakers and condensers of a special shape and label, but a *question put to nature*, either for the sake of just knowing what nature's answer will be, or for the sake of deciding a difference of opinion. One of the sad things about laboratory work whether in Junior High School, Senior High School, or College, is the small space left for the gratification of that natural curiosity which is the primitive endowment of man, and which has borne him onward in his struggle for a worthwhile civilization. Our ideal seems to be embodied in some lines of Tennyson's, although we have twisted them in a manner which I am sure Tennyson never intended:—

"Theirs not to reason why;
Theirs but to do....."

and be marked upon the doing.

While advocating individual experimentation in the school laboratory, if possible, I am well aware that this is impossible, and perhaps even undesirable in some cases. Under such circumstances certain types of home experimentation are possible, especially if the pupil who has carried out an experiment in a significant manner at home, brings the apparatus to the class-

room and performs the experiment there. The student should by all means be encouraged to try out his ideas with apparatus, if this is feasible, and if he can do so without danger. If he cannot do this at home, or in a set laboratory, he can often carry it out in class as a part of some demonstration by the teacher. Right here I wish to protest against long-range demonstrations or lectures. The fact is that the words of wisdom emanating from a lecture's or demonstrator's desk, in circles far above the Junior High School, in point of the age of the pupil, do not get very far from the aforesaid desk. This is especially true of a demonstration with clear, glass appara. tus. All details of such apparatus may be blurred to the pupil at the back of the room, and that which the pupil sees may be totally different from that which he is supposed to see. If demonstrations must take the place of individual experimentation, in Junior High School courses in General Science, the class should by all means be small, and the demonstration sufficiently informal, so that the pupils can come near the lecture table to see what is going on, and to get a bit, at least, of the "feel" of the apparatus.

As has already been said,the methods of instruction may vary, but the purpose of the General Science course must be substantially the same, whether the course is given in the Junior High School or in the four-year High School. The understanding of the world about him is what the pupil needs. In his life experience the pupil will get more of the "practical" and "commercial" than he will of the cultural, which is, after all has been said, the *fundamental*. Therefore the science course should give him some basic knowledge of those phenomena and laws which, for special purposes, we call physical, chemical, and biological. These are the only sure foundations for a sane study of the future, whether of practical subjects or of further cultural studies. This is true likewise for the growing knowledge which will come even to those whose means or condition render further schooling of the formal sort impossible. Science study is a sane preparation for a sane State.

The Adaptability of General Science in the Last Three Grammar Grades. Test Topics. [1]

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With very few exceptions, general science courses are intended for the use of pupils in their first high-school year. Of the eighteen general science texts examined in the spring of 1919, only one was admittedly designed for the grades. It is a fact, however, that in many places a general science course is given in one of the years which constitute the junior high school seventh or eighth grade, one of the simpler texts being persumably used.

It is by no means a generally accepted principle that general science should be placed exclusively in the high school—that it is unsuited for the grades. In the great reorganization which world events are forcing upon the methods and curricula of schools, in which the demand for a useful knowledge of environment is drowning out the defensive arguments for courses of abstract and remoter value, more than one voice speaks for an earlier introduction to nature by instruction in her simpler principles given to children even in the lowest grades.

Certain important principles in the selection of subject-matter for science instruction in the grades may only be determined by experiment. There is excellent agreement among authors of general science texts as to the suitability of a large number of the topics of the five principal sciences; but could the same subject-matter be used in the grades, even in simple form? For example, could the meteorological causes of winds and storms (17 texts), the types of energy, momentum, inertia, etc. (15 texts), the botany and chemistry of photosynthesis (16 texts,) the chemical composition of the atmosphere (16 texts), be explained to sixth-grade children in a manner which would really result in their assimilation and understanding of the principles involved?

For science instruction in the grades, may topics from the five principal sciences be used in equal amounts? May they be used in the same proportion as they now occur in general science, or in some other proportion suggested by experiment?

1 Extracts from pamphlet, "General Science Instruction in the Grades."

May suggestions be obtained from experimental evidence as to the assimilability, or average amount of possible understanding, which children will show to each of the five principal sciences in the grades, to determine if this assimilability is uniform?

If assimilability is not uniform, which science should predominate in the instruction in each grade? What are the relative amounts of the other sciences which may be acceptably included in that grade? If a certain science such as chemistry, is not suitable for instruction in the sixth grade, in which grade may its topics be profitably included?

These and many other questions have prompted the study which follows:

SELECTION OF THE TEST TOPICS.

The subject-matter of general science has been principally obtained from five sciences. It was planned to select 25 important and characteristic topics from each of these sciences, choosing only those which occur in a clear majority of the texts. In physics there are more than 25 topics each of which is found in ten or more texts; in the other sciences there are less than 25 such topics. The zoology section of biology contains no topic included in ten texts; but to avoid eliminating the subject altogether, five leading topics were chosen from zoology, which, added to 20 topics from botany, fills out the quota for biology.

In choosing the particular fact of science upon which the statements of the "test topic" were to be based, a minute division of each topic was treated in the various texts. These subtopics were recorded, and ranked according to the number of texts in which each was treated. For example, the first topic of physics, "Transfer of heat" (18 texts), is composed of the subtopics, "Convection" (16 texts), "Conduction" (15 texts), "Types of furnaces" (15 texts), "Radiant heat" (14 texts), "Practical ventilation" (11 texts), and nine other items of minor rank. Since but one subtopic is to be selected, and that must be the one most prominently treated, the choice falls upon the principles of convection, which is discussed in the largest number of texts. In a similar manner the most important subtopic of each of the 25 most highly ranked topics in physics was selected.

In the other sciences, where less than 25 topics were included in a majority of the texts, it was necessary to select two or more subtopics from the topics which had the greatest number of pages. For example, in physiography three subtopics each were chosen from the first three topics, since these contained more pages than the others, and two sub-topics from each of the remaining eight topics, making 25 in all. In determining which three subtopics were most prominent in the topic—that of "Humidity and precipitation" (17 texts), for example—the component items were found to be, "General cause of humidity" (17 texts), "Rain" (17 texts), "Snow" (16 texts), "Clouds" (16 texts), "Dew" (11 texts), "Frost" (11 texts), and nine other minor ones. The three subtopics chosen were rain and snow, clouds and fog, dew and frost, since these were clearly predominant and occur in a majority of the 17 texts mentioning Humidity.

In a similar manner, all of the 125 "test topics," 25 from each of the five principal sciences, were selected. These subtopics are those which rank highest in their respective topics; the topics are the most important of their respective sciences; all (except five in biology, from the zoology division) occur in a clear majority of the eighteen texts. It is believed that this method has resulted in the selection of test topics thoroughly characteristic of each science, each topic representing the most favorable judgment of more than a majority of the authors of general science texts as to its fitness to be presented as a part of the instruction in his text.

Following a special study of the texts as to language and treatment of each selected topic, the test which was to be put into the hands of the children was prepared, consisting of a little folder of four pages fastened together.

Page 1

TO EACH BOY AND GIRL:

This is a game to see how well you can remember. Here are the rules:

1. DO NOT TURN ANY PAGE OVER, OR LOOK AT IT, UNTIL THE TEACHER TELLS YOU TO DO SO.
2. WHEN THE TEACHER TELLS YOU TO, WRITE ANSWERS TO THE QUESTIONS.
3. ON ONE PAGE THERE IS SOMETHING TO READ. TRY TO REMEMBER IT IF YOU CAN.
4. DO NOT LOOK AHEAD, AND DO NOT LOOK BACK, AT ANY PAGES.

Page 2.

A question designed to discover whether the child already has a knowledge of the principles of the test topic. This question was di-

rect, simple, and usually covered one point only. If answered correctly, it would be evident that the child possessed some apperceptive basis for the further consideration of the particular topic involved. If answered incorrectly, it would appear that the child either had no previous conception of the subject or was unable to express one. The data obtained from the answers to this question were expected to be a measure of the foundation of previous knowledge upon which instruction in general science in the grades might be built.[1]

Page 3.

A direct statement, in which the facts and principles of the test topic were set forth as clearly and simply as possible. While a strict composite of the discussions in the ten or more texts was impossible, the statement was carefully worded after a study of the language of each text. Illustrations accompanied this paragraph in thirty-five instances.

Page 4A.

One or more direct questions, calling for the specific information given on the preceding page. A correct answer would be evidence that the child has been capable of understanding the subject-matter of the statement; and the further inference is not unreasonable that similar statements, equally characteristic of the science and of approximately the same degree of complexity, might also be assimilated by the child. An incorrect answer, or no answer, might indicate that the topic was apparently too complicated for the child's understanding, and that he would probably have difficulty, or fail completely, in the assimilation of similar topics in that science.

Page 4B.

One or more questions, based on the specific information of the statement on page 3, but involving a further step of reasoning along some closely related line. A correct answer would indicate that the child not only understood the topic, but was able to apply its principles to the solution of another problem such as might be next propounded by text or teacher in ordinary recitation. An incorrect answer would warrant the conclusion that the principles of the statement, even if understood by the child, were in isolated position in his mind, and not sufficiently correlated with his appreceptions to be of practical value.

Lines for the grade, name, and age of the child headed each sheet, so that they could be identified if separated.

Special effort was made to avoid questions which could be answered by mere "yes" or "no," or in which the choice of one alternative without explanation would suffice, the laws of chance predicting correct answers in 50 per cent of such cases. The use of certain words, familiar enough to adults, but possibly strange to the child, such as "explain," "illustrate," "describe," "discuss," etc., was discarded in favor of the simpler phrases, "Tell about it," "What is," "Why is," etc.

1 For a similar test of certain phases of Chemistry in beginning classes, see Webb, H. A., "A Preliminary Test in Chemistry," Journal of Educational Psychology, Vol. X., No. 1, page 36 (January, 1919).

It is fully realized that in some instances the wording of the statement and questions might have an undue influence for correctness or incorrectness of the answer. This condition is minimized in two directions, however: first, the language, in practically every case, is essentially that of one or more texts, simplified as to words or difficult phrases, or at least is as typical of all texts as a close study was able to determine; second, in twenty-five test topics for each science a few statements or questions of more than the average difficulty would probably be compensated by a few of abnormal simplicity. The combined results for all twenty-five test topics would thus be a fair measure for the science as a whole.

With each package of test topics sent out, letters to teachers explaining the spirit of the test were inclosed, and also a page of specific directions. The number of minutes which were to be allowed a child for writing answers to each question, and for studying the statement, was determined by some preliminary experiments in the Demonstration School of George Peabody College for Teachers. The object was to give sufficient time for even slow pupils to finish, and the indicated periods were found to be ample.

DIRECTIONS TO THE TEACHER

(This test is for the last three grammar grades only.)

In order that there may be uniformity in the methods by which this test is given, it is requested that the teacher in charge of the pupils use the method and wording below:

Step 1.

(The teacher should see that each child has a pencil, and that the teacher has a watch or can see a clock.)

Teacher (to children): "Girls and boys, here is a new game. I am going to have placed on each desk some sheets of paper, face downward, and you must not touch or handle them until I tell you to."

(Have the sets, four small pages each, quietly distributed, face downward.)

Step 2.

Teacher (to children): "Now turn the whole thing over, and let us read the rules together." (The reading should be done in concert, or by the teacher plainly and with emphasis, the children reading silently.) The rules—

TO EACH BOY AND GIRL.

This is a game to see how well you can remember. Here are the rules:

1. DO NOT TURN ANY PAGE OVER, OR LOOK AT IT, UNTIL THE TEACHER TELLS YOU TO DO SO.
2. WHEN THE TEACHER TELLS YOU TO, WRITE ANSWERS TO THE QUESTIONS.
3. ON ONE PAGE THERE IS SOMETHING TO READ. TRY TO REMEMBER IT IS YOU CAN.
4. DO NOT LOOK AHEAD AND DO NOT LOOK BACK, AT ANY PAGES.

Step 3.

Teacher (to children): "Now turn the first page over. Write your grade, name, and age on the first line. Then answer the question or questions below if you can. I will tell you to stop in just two minutes. If you finish before that time, sit quietly, and do not turn any pages."

(Allow exactly *two* minutes for the writing.)

Step 4.

Teacher (to children): "Now turn the page over. You must not turn it back again. Write your grade, name, and age. Read what is written on this page, and try to understand and remember it. Do not turn the page until I tell you to. You will have two minutes to study."

(Allow exactly *two* minutes for study.)

Step 5.

Teacher (to children): "Now turn the page, and do not turn it back again. Write your grade, name, and age on the first line. Answer the questions if you can. I will stop you in four minutes; but if you finish before, sit perfectly still, and do not change what you have written."

(Allow exactly *four* minutes for this writing)

(The papers should now be promptly collected without alteration.)

TEST TOPICS IN PHYSICS[1]

1. *Page* 2.

Question 1. Why, in winter, is it always colder in a room near the floor than near the ceiling?

* * *

Page 3. CONVECTION CURRENTS. (Illustrated.)

Statement: Whenever air becomes warmer, it expands; and because this makes it lighter, it rises. Cold air contracts, is heavy, and falls. In a room the warm air goes to the ceiling, while cold air comes in along the floor.

The same thing is true of water. If a bucket of water is heated, the warm water goes to the top, and cold water to the bottom.

This movement of air or water, due to a difference in temperature, is called "convection."

Page 4.

Question 2. Tell why warm air or water rises, and cold air or water falls.

Question 3. Why do the boilers of big factories have such tall chimneys? Why would not a short chimney do as well?

2. Thermometers. (Illustrated.)
3. The Pressure of Air. (Illustrated.)
4. The Kinds of Energy.
5. The Three States of Matter. (Illustrated.)
6. How Heat is Measured.
7. The Lever. (Illustrated.)
8. Magnets. (Illustrated.)
9. Specific Gravity.
10. How Suction is Caused by Air Pressure. (Illustrated.)
11. How Light is Reflected. (Illustrated.)
12. The Inclined Plane. (Illustrated.)
13. The Force of Gravitation.
14. The Spectrum Colors, or Rainbow. (Illustrated.)
15. Electromagnets. (Illustrated.)

1 A complete set of the test topics in the mimeographed form as sent out may be secured by any interested person on application to the author.

16. The Boiling and Freezing Points of Water.
17. How Ice is Made.
18. The Bending of Light Rays. (Illustrated.)
19. How Coal Has Been Made.
20. How Electric Dynamos and Motors Work.
21. How a Steam Engine Works.
22. Expansion of Substances When Heated.
23. The Nature of Light.
24. Artificial Lighting.
25. The Nature of Sound.

TEST TOPICS IN PHYSIOGRAPHY.

1. *Page* 2.

Question 1. Rain, or snow, is water falling from the sky. How does the water get up into the sky?

* * *

Page 3. RAIN AND SNOW.

Statement: As warm air blows across oceans and lakes, it gathers much water vapor from their surfaces. The winds blow this moisture over the land in the form of clouds. The tiny drops of water which form the cloud gradually make larger drops by running together, and fall to the ground as rain.

If the moisture in the cloud freezes before it starts to fall, it comes to the ground as snow.

Page 4.

Question 2. Where does the water in the sky come from, and how does it turn into rain? Why does the water in the sky sometimes turn to snow instead of rain?

Question 3. Why do big clouds sometimes go sailing by without any rain, and why do they at other times pour rain upon the earth?

2. Clouds and Fog.
3. Dew and Frost.
4. High and Low Pressure of Air.
5. A "Cold Wave."
6. Wind Belts of the Earth.
7. The Kinds of Soil.
8. How Soil Has Been Made.
9. What Soil is Made Of.
10. Forecasting the Weather.
11. The Work of the United States Weather Bureau.
12. How Caves Have Been Formed.
13. Springs and Wells.
14. How a Stream Sorts Out Rocks of Different Sizes.
15. The Cutting of Valleys. (Illustrated.)
16. Deltas and Flood Plains. (Illustrated.)
17. The Irrigation of Desert Lands.
18. Swamps and Drainage.
19. How Coal Has Been Made.
20. What Coal is Made Of.
21. Climate.
22. The Effect of Lakes and Ocean on Climate.
23. Igneous Rocks, Rocks That Have Been Melted.
24. How Limestone is Formed.
25. The Cause of Lightning and Thunder.

TEST TOPICS IN BIOLOGY.

1. *Page* 2.

Question 1. Where do trees get the material to make wood out of while they are growing?

* * *

Page 3. THE FORMATION OF STARCH IN PLANT LEAVES.

Statement: Leaves are the food makers for the plant. Two substances unite in the leaves: (1) The carbon dioxide gas from the air; (2) water coming through the roots and up the stem.

These two substances unite in the leaves to form starch. This can only happen while the sun is shining. At night the starch which has been made during the day is carried to all parts of the plant. This is what makes the plant grow.

Page 4.

Question 2. Tell how a plant manufactures starch in its leaves. What becomes of the starch after it is made?

Question 3. If a plant is placed in a dark cellar, will it grow much? Tell exactly why.

2. The Green Substance in Leaves.
3. The Fungus Plants. Molds.
4. The Yeast Plant. (Illustrated.)
5. How Flowers Make Fruits. (Illustrated.)
6. The Parts of a Flower. (Illustrated.)
7. The Purpose of Roots. (Illustrated.)
8. The Forms of Roots. (Illustrated.)
9. The Nitrifying Bacteria. (Illustrated.)
10. Good and Bad Germs.
11. How Seeds Are Scattered.
12. How Seeds Grow. (Illustrated.)
13. The Stems of Trees. (Illustrated.)
14. Trees and Their Uses. (Illustrated.)
15. Germs, or Bacteria. (Illustrated.)
16. How Germs, or Bacteria, Reproduce. (Illustrated.)
17. The Purpose of Leaves.
18. How Leaves Help the Plant.
19. How Plants Use the Air.
20. How Plants Use the Water.
21. The Life History of Insects.
22. The Body of a True Insect. (Illustrated.)
23. The Kinds of Animals.
24. The Life History of a Frog. (Illustrated.)
25. The Simplest Animal, an Amoeba. (Illustrated.)

TEST TOPICS IN PHYSIOLOGY.

1. *Page* 2.

Question 1. How do catching dieseases, like measles, get from one person to another?

Page 3. THE CAUSE OF DISEASE.

Statement: All catching diseases are due to tiny germs, which may live in our nose, our throat, our lungs, our intestines, our blood, and in other parts of our body. These germs get into our body when we do various things which are not healthy, such as drinking impure water, eating food on which flies have walked, drinking from cups that other people use, etc. In fact, if we carelessly handle anything that sick people have used, the germs from these sick persons may get into our bodies and give us the disease.

Page 4.

Question 2. How does one person catch a disease from another? What are the best ways to keep from catching diseases?

Question 3. Do flies ever do us any harm? Why should we try to keep flies away from our food?

2. Where Germs are Found in the Body.
3. Toxins and Antitoxins.
4. How Germs May Be Killed.
5. How Water is Purified.
6. The Impurities in Water.
7. Pure Water to Drink.
8. Insects Which Carry Disease.
9. Flies and Typhoid Fever.
10. The Cause of Malaria.
11. The Gases in Our Lungs.
12. How We Breathe. (Illustrated.)
13. The Structure of Our Lungs. (Illustrated.)
14. The Digestion of Food in the Mouth.
15. How Food is Digested in Our Intestines.
16. How Food is Digested in Our Stomach
17. Defects of the Eye. Far-sight and Near-Sight.
18. How Poor Light Hurts the Eyes.
19. How the Eyes See. (Illustrated.)
20. The Harmfulness of Alcohol.

21. The Harm of Patent Medicines.
22. How Tobacco Harms the Body.
23. Our Heart. (Illustrated.)
24. What the Blood is Made Of.
25. The Blood Vessels.

TEST TOPICS IN CHEMISTRY.

1. *Page* 2.

Question 1. Why must fire in a stove have plenty of air before it will burn?

Page 3. WHY THINGS BURN OR RUST.

Statement: Whenever anything burns, it unites with oxygen gas from the air. Since only about one-fifth of the air is oxygen, a substance would burn more vigorously in a bottle of pure oxygen than it would in air.

Some substances such as paper, wood, coal, etc., unite with oxygen very rapidly. These burn easily, and with much flame. Other things, such as iron, lead, and other metals, unite with the oxygen of the air very slowly, and become covered with rust. Rusting and burning are similar processes, except that burning is a more rapid union with oxygen than rusting. In pure oxygen a hot iron wire would not rust, but would catch fire and burn.

Page 4.

Question 2. In what way is the burning of wood and the rusting of iron alike? In what ways are burning and rusting different?

Question 3. Does the oxygen which we breathe from the air have anything to do with the warmth of our skin? Tell about it.

2. Flames, Kindling Points.
3. The Gases of the Air.
4. The Air is a Mixture.
5. The Properties of Oxygen.
6. The Preparation and Properties of Oxygen.
7. Carbon Dioxide Gas.
8. Carbon Dioxide as a Fire Extinguisher.
9. What Water is Made Of.
10. The Composition of Water.
11. Atoms and Molecules.
12. Elements, Mixtures, and Compounds.
13. The Properties of Hydrogen.
14. Preparation and Properties of Hydrogen.
15. The Hardness of Water.
16. How Washing Soda Helps in Washing.
17. Physical and Chemical Changes.
18. Physical and Chemical Actions.
19. How Nitrogen is Prepared From the Air.
20. Acids, Bases, and Salts in the Home.
21. Acids, Bases, and Salts.
22. How Crystals are Formed. (Illustrated.)
23. How Things Dissolve in Water.
24. The Properties of Phosphorus.
25. How Matches are Made.

ANALYSIS OF THE SAMPLING.

The 9,819 test sets returned represented exceedingly fair sampling, as indicated by the following tables:

Grand Total, by Grades.[1]

5	1239	7x	1122	8	1880
6x	1201	6r	2072	7r	2305

The higher grades in each group show slightly fewer replies, as expected.

1 In this table **x** refers to grade in a 5-6-7 group and **r** to a grade in a 6-7-8 group.

Grand Total, by Science.

If the distribution had been perfect, each science would be represented by 1,964 answers. The number of answers received, and the deviation from this average, is recorded:

Science	No. Answers	Dev.
Physiology	2032	+68.
Physiography	2001	+37.
Physics	1957	—7.
Chemistry	1933	—31.
Biology	1896	—68.

The count shows a remarkable uniformity. The slight deviation is almost perfectly symmetrical. The extreme range out of nearly two thousand answers is only 136. The various deviations from the average of 1,964 average only 43, or 2.2%.

Totals in Each Science, by Grades.

Science	5	6x	7x	Science	6r	7r	8
Physiology	291	229	214	Physiology	439	486	373
Physiography	231	245	235	Physiography	433	466	391
Physics	257	239	224	Physics	421	446	370
Chemistry	230	260	218	Chemistry	384	464	377
Biology	230	228	231	Biology	395	443	369
Average	248	240	224	Average	414	461	376
Av. Deviation	21	10	7	Av. Deviation	20	15	6

These data show that the tests were distributed with great uniformity to the separate grades, and that there is no marked excess or deficiency of answers in any science or in any grade. The fairness of the sampling seems to be thoroughly demonstrated.

METHOD OF GRADING

Each of the 29,457 questions was individually marked by the writer. They were taken in the unsorted order, just as received from the superintendents. In this way the possibility of the mind getting into a certain "track" in marking a large number of identical questions was avoided—a condition in which reasonable variations in answers might not be properly judged. The grading was done almost continuously day after day, and thus the point of view remained reasonably constant throughout the entire time. No tabulations of any kind were made until after all the grading was completed. Thus it was impossible to tell the tendencies which were developing or to receive any information which might bias the judgments in any way.

SUMMARY OF INTERPRETATIONS.

1. A representative list of the principles of science cannot be effectively presented to children of the fifth grade and below. They lack a sufficient apperceptive foundation of previous experience; they are not able to directly assimilate any reasonable number of characteristic ideas of science and express them again; their minds have not sufficiently developed so that powers of logical reasoning might be expected.

2. In the sixth grade, physiology and physiography alone seem to be suitable for science instruction. There is a reasonable amount of previous knowledge possessed by children in this grade, and the characteristic and fundamental topics of these sciences seem to be satisfactorily assimilated and logically applied according to the standards suggested.

3. In the seventh grade, biology, and possibly a most elementary treatment of physics, becomes appropriate according to similar standards.

4. In the eighth grade, physics is acceptable for instruction according to similar standards.

5. That chemistry is of doubtful value for instruction in any of the grammar grades, since its percentages in previous knowledge, direct assimilation, and power of application, all fall below the suggested standards, which are easily attained by children of some grade or grades in the other sciences.

* * * * *

The first power to develop in a child is that of direct assimilation, and this ability keeps ahead in all development. A text in science written for the grades must abound in direct statements of fact, plain illustrative material, and leave little to be inferred. Successful teaching of science in the grades must be judged largely by the extent to which children master the direct assignments of the day. An equivalent success in reasoning from the simple facts learned must not be expected. A book which is full of the so-called "thought questions" is not altogether the best for grade instruction, however applicable that method may be to high-school classes. The powers of logical reasoning have not yet developed in the minds of grade children, and abstract principles cannot be visualized by them.

Neither can reliance be placed on any appreciable previous

knowledge possessed by the children. For the grades, science must be even more simple in idea than in language. An eighth-grade child is abundantly able to read a fairly technical discussion concerning the hardness of water, or the magnetic field through a coil of wire; but it is not at all certain that he has ever inquired into the reason for the use of ammonia or soda in the home, or that he has ever taken the cover off an electric bell.

In fact, the self-acquired knowledge of children goes but little beyond the observation of obvious cause and effect. The much-proclaimed curiosity of children rarely searches out principles. It would seem that the most familiar objects would be the best understood, but the tendency to take familiar things for granted largely neutralizes the spirit of inquiry. This tendency often persists even to adult life. The writer found, in a study of the previous knowledge of several hundred of his normal and college students, in beginning chemistry, that over half of them did not know whether air was one substance or a mixture of substances. The question arises: How familiar must a thing be in order that the facts about it may be common knowledge?

The method of science instruction in the grades should make full use of the predominant power of the child to directly assimilate facts—an ability well illustrated by the well-known ease with which they master the language. Efforts to cause powers of reason and observation to function when by the laws of child psychology these powers are in a rudimentary stage of development will result in waste of energy on the part of both teacher and child. As the use of general science spreads to the grades, it is hoped that both content and method will be built upon a firm foundation of educational principles determined by experiment.

Cooperative Work in the Organization of Local Material for General Science Instruction: Water Supply Systems.

The Water Supply System of Oakland, California.

EARL R. GLENN, The Lincoln School of Teachers College, Columbia University, New York.
ANNA LOWREY, Berkeley, California.
BESSEY K. GISH, East Technical High School, Cleveland, Ohio.
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OUTLINE:

I. Introduction.
II. Part I. The Oakland, California, Water Supply System.
III. Part II. The Water Supply System of Cleveland, Ohio.
IV. Part III. The Water Supply System of Muskogee, Oklahoma.
V. Part IV. The Philadelphia Water Supply System.
VI. Part V. The New York City Water Supply System.

I. INTRODUCTION:

During the summer of 1921, a group of general science instructors at Teachers College held a series of informal meetings for the purpose of developing units of general science instruction that would be based upon the water supply systems of the cities represented by the various teachers in the group. We decided to assemble samples of student work, arranging them in the form of an exhibit, which could be sent from teacher to teacher for classroom use. The first exhibit of this kind was based on the New York City Water Supply. In the meantime, Miss Bessey K. Gish of the East Technical High School of Cleveland, Ohio, and Miss Grace Musch of Muskogee, Oklahoma, furnished similar exhibits for the series.

All of these local exhibits have been assembled to make one large exhibit bearing upon the various features of public water supply. This material is sent from one teacher to another.

One of the problems of science teaching is that of developing units of instruction based upon the particular needs of the community. No text book organization, as such, is a substitute for this type of organization. On the other hand, it is extremely difficult, because of the necessary expenditure of time and

money, for a teacher to make such an organization. The situation is further complicated by the fact that many teachers do not begin such work simply because they do not anticipate a long stay in any one community; if they do make a beginning, they carry their plans with them when they move.

It has seemed advisable to publish some of these preliminary outlines in order that teachers may see how to begin the organization of local science material. It is probably true that they will be unsatisfactory in certain respects, and will require careful revision before further use in the class room. The formulation of such a preliminary outline is one of the most difficult aspects of the teaching process. With a preliminary plan as a guide it is relatively easy to develop a satisfactory order for teaching the essentials of this unit of the course.

We hope this series of outlines will stimulate other teachers to study their own communities with the idea of making similar organizations of local material. After teaching several classes according to the preliminary outline, it will be possible for the teacher to formulate a plan which will be much more satisfactory from his own point of view.

Part I: The Oakland, California, Water Supply System.
Lesson I. Sources of Water.

PURPOSE: To give the pupils a general idea of the numerous sources from which people may obtain water for home and commercial uses.

ASSIGNMENT: (Given the previous recitation)

1. Read two of the references given on the mimeographed information sheet, under the title of "Sources of Water."
2. Make a list of the water supply sources which you know about or would like to know.

CLASS DISCUSSION:

Which of the sources of water supply are most common in Alameda Co.? In California? In the city? In the country?

Give the advantages of securing water from wells; springs; rivers; storage reservoirs; lakes; and the ocean.

List the disadvantages of each of the sources mentioned.

From which of the sources mentioned does the city of Oakland secure water for domestic use? For fire fighting?

NEW ASSIGNMENT: (Facts we should know about the Oakland water system).

1. Location of the water sources. (GROUP I.)
   - a. Lakes
   - b. Reservoirs
   - c. Artesian wells
   - d. Ocean subsidiary

Directions: Bring t oclass 3 maps, namely:

a. One showing the East Bay Water Ways and mountain chains.

b. One showing the East Bay cities.

c. One showing the whole San Francisco Bay region as far north as San Pablo Bay.

Good maps will be found in:

Begmann, Werner—"Report on a City Plan for the Municipalities of Oakland and Berkeley."

Fairbanks, Harold. "Geography."

Make the copies five times the original size in the books.

2. History of Oakland water supply. (GROUP II.)
   - a. Early history up to 1900.
   - b. 1900-1919
   - c. 1919-1921
   - d. Pictures
     - Newspapers
     - Magazines
     - Photographs

Directions: Assign a topic to each member of the group. All information desired will be found in any public library branch under the topic "History of Oakland and Berkeley" and "History of Alameda County."

3. Relation of population to amount of water used. Compute the amount of water needed by the East Bay section. GROUP III.
   - a. 1880-1900
   - b. 1900-1910
   - c. 1910-1920

Directions: In Smith & Jewett's "Introduction to Science," the amount of water consumed per capita is given on p. 187. In any encyclopaedia, atlas, or city report the figures for population can be obtained.

It will be necessary to take the population of Alameda, Albany, Berkeley, and Oakland separately.

The chairman will assign parts to each member of the group.

4. Growth of population. Charts. (GROUP IV.)
   a. 1880-1890
   b. 1890-1900
   c. 1900-1910
   d. 1910-1920

Each decade is to be enumerated separately on a large piece of manila wrapping paper. Use black crayon.

5. Things to know about the ownership of the water supply: (GROUP V.)

a. Is it municipally or privately owned?
b. How is the Los Angeles system owned? San Francisco?
c. Who controls the Berkeley system?
d. Find out some advantages for municipally owned water supply.
e. Find out some advantages for privately owned water supply.
f. Find out some disadvantages of municipally owned water supply.
g. Find out some disadvantages for privately owned water supply.

Lesson II. Facts We Should Know About Oakland's Water System.

PURPOSE: To give each pupil a general knowledge of the sources of the water, who controls the sources, and some idea about the changes in the sources and control of this water supply.

CLASS DISCUSSION: Report from Group I on location of sources. Each child makes notes of the points he gets from the report. The maps are hung up in the room

and the water sources are marked with tin foil pasted on the maps.

Report of Group II. Pictures displayed.

Report of Group IV. Population charts. Discussion.

QUESTIONS: Compare the location of Lake Chabot and and San Pablo Reservoir.

How far from Oakland is Lake Chabot? San Pablo reservoir?

How long would it take to go to either place by trolley? By automobile?

From the location of these water sources what would you think was the character of the land, and the vegetation around them?

From what water sources would Lake Chabot be fed? San Pablo Reservoir?

Why is Oakland more concerned about the water supply now than in 1890?

Do you prefer the present system or that of 1900? Why?

ASSIGNMENT:

1. Notebook work: Make a memorandum of the facts you have heard discussed which you think you should remember and which you think every member of the Oakland community should know.
2. Why did the East Bay secure water rights in Contra Costa County in 1919? Why does the East Bay wish control of the lands in this county?

Lesson III. The Topic of Lesson II Is Continued.

CLASS DISCUSSION: Report of Group V: Ownership and control of water supply system.

Might private ownership encourage spread of typhoid fever?

How are private owners made responsible for the character of the water sold to the people?

Report of Group III. Population and water consumption.

Write a paragraph summarizing the reports of these committees.

ASSIGNMENT: Information about each water source.

GROUP I. Lake Chabot—What is its drainage area? Depth? Water surface? Daily capacity?

Refer to the Oakland Tribune, Annual No. 1918. Oakland Post Enquirer, Annual No. Jan. 1922.

GROUP II. Alvarado Wells—Locate and mark with white headed pins, stuck into the map in the class room. Are they surface? Artesian? How much water do they supply? Write a paragraph on the soil in this district.

GROUP III. Hetch-Hetch Project—What is it? Where is it? What federal trouble has there been over it? How is Oakland concerned with this?

GROUP IV. Auxiliary System—What is it? How is it used? How is its water put into the regular system?

GROUP V. San Pablo Project—Where is it? When will it be used?

Refer to Oakland Tribune, Annual No. 1920.

Lesson IV. Important Facts to Know About Each Source of Water Used in the Oakland Water System.

PURPOSE: To enable the pupils to know a little about the extent and inclusiveness of the system which they use daily.

CLASS DISCUSSION: Reports from each of the five groups. Each pupil is to record a short paragraph about each topic reported.

ASSIGNMENT:

Preparation for a trip to San Pablo Reservoir.

COMMITTEES:

1. To get permission from the Superintendent of the water works.
2. To secure a permit to enter the grounds of the East Bay Water Company.

3. To secure autobus to take the class.
4. For taking snap shots of interesting things to be seen at reservoir.
5. Lunch.

Lesson V. The Trip To San Pablo Reservoir. (See Fig. 1)

PURPOSE: To give the pupil real interest in his community; to make him realize the greatness of his scientific age; to stimulate his interest in science by causing him to wonder how these engineering achievements are accomplished.

Fig. 1. SAN PABLO DAM AND RESERVOIR.[1] Capacity 14,000 gallons with daily safe yield of fifteen million gallons.

OUTLINE FOR THE EXCURSION.
(Copy to be placed in the hands of each pupil)

Fill in the blanks during the trip.

THE RESERVOIR:

1. San Pablo reservoir is ..... miles from Oakland and is in the ..... range. It is ..... of Berkeley.
2. The reservoir covers ..... of land.
3. Its depth is .....; length .....; drainage area .....; capacity .....; cost .....

1 Reproduction from "Collecting and Distributing a Domestic Water Supply." Paul I. Daniels, 1921.

4. It is so located so as to receive the water from .....
5. Its dam is of ..... and has a ..... to water seepage.
6. Its dam is one of the ..... of its kind in the world.
7. The dam is ..... wide at its base, and .....wide at its crest. The crest is ..... long.
8. The dam is ..... high from creek bed to crest.
9. .....cu. yards of material were used in the construction of the dam.

TRANSFERRING THE WATER:

1. How is the water carried from the reservoir to Oakland?
2. The conduit through the hills is made of the ..... which is lined with .....
3. This tunnel is ..... long. It is large enough to drive ..... through it.
4. The advantages of this tunnel are:
   a. .....
   b. .....
5. The spillway at the tunnel and Wild Cat Canyon are to relieve .....

CONTROL TOWER:

1. The control tower ..... the water through the .....
2. The water is drawn at different depths.
   The depth from which it is drawn is governed by ..... conditions.
3. The control tower governs ..... outlets ..... apart.
4. The water from the tower is deposited in a ..... plant located ..... of Berkeley.

THE FILTER PLANT:

1. The ..... features of all the great city filter system are incorporated in this filter system.
2. This filter is a ..... filter.
3. The water is ..... up in the air and allowed to fall in an .....
4. The coagulation basin is ..... long; ..... wide; used to ..... by employing .....
5. The filters are located in ..... in groups of ..... Each filter is ..... wide by ..... long by ..... deep, and cleans ..... daily, and has a sand area of .....
6. The filters remove the ..... and other ..... matter.
7. These filters are cleaned by allowing the water in from the ..... side.
8. The water stands ..... feet in aerator and ..... feet in pure water reservoir.
9. After being filtered the water is ..... by using ..... parts of chlorine to ..... parts of water.

MISCELLANEOUS:

1. The grounds are .....
2. The elevation is ..... and is sufficient to supply ever part of Oakland, Berkeley, Fruitvale, Albany, Emeryville and Richmond.
3. This reservoir prepares for the growth in population within the next ..... after 1920.

Lesson VI. Discussion of the Class Excursion.

QUESTIONS: How is the water conducted over the hills of Contra Costa?

Why did not the Water Company carry the pipes down Wild Cat Canyon?

Why is this method of advantage to the cities of the Bay region?

Why is there a control tower or auxiliary pump?

By what means is the water drawn through the tunnel?

How is the water taken to the filter?

Describe the process of cleaning the water.

How are the filters cleaned?

Why is it necessary to use chlorine after filtration?

How many miles long is the tunnel?

How is the water carried from the aerator to the pure water reservoir?

Write a summary describing the points which you think every boy and girl in Oakland should know.

ASSIGNMENT: 1. Construct a diagram of the San Pablo water system as found in the Oakland Tribune for January, 1920; p. 109.

2. Would you like to drink the city water now that you have seen its source? Why? Are you sure that it is pure? How could we find out that it is safe to drink?

3. Appoint two boys to go to the State Sanitary Engineer's Office in Berkeley to get sterlized bottles for state analysis of school and other water used in the community.

4. Show two children how to make some demonstrations for the class on vegetable and animal matter in water.

5. What does the bacteriologist mean by "control"; "B. coli."?

6. What does the chemist mean by "precipitate"; "distillate"?

Lesson VII. What is "Pure" Water?

PURPOSE: To show pupils that even though water may seem pure, yet it is not always so, even when it sparkles.

CLASS DEMONSTRATION:

1. The filling of sterile bottles from Berkeley according to the directions given.

2. Distillation apparatus—is set up by teacher and is ready to operate upon the arrival of the class.

THE PROBLEM: Are there some dissolved substances in Oakland water?

TEACHER:

a. Test for hardness of tap water. Observation.
b. Place tap water in flask over flame and distill it. Observation.

PUPILS:

c. Fill a clean bottle two-thirds full of tap water, shake vigorously, smell immediately. Observation. Apply one test for plant matter.
d. Allow a glass of water to stand covered a day. Observation.
e. Heat 50 cc. of water to boiling in a beaker, covering with a glass plate. Lift the cover. What does the odor indicate?
f. Allow the water to stand awhile. What is your observation?

SPECIAL TEST BY TWO PUPILS:

Purpose: To test for vegetable material, with potassium permanganate.

Material: Distilled water, solution of potassium permanganate, 2 beakers, sample of drinking water, small pipette.

Operation: Beaker 1: 50 cc. of distilled water.
Beaker 2: 50 cc. of water to be tested.
In each place one drop of potassium permanganate solution. What happens? Compare the color of the solutions in the beakers. Boil solution II a few minutes and allow to cool. How do the two beakers of solution compare now? Any change from pink to brown in II indicates the presence of vegetable substance. What was the control in this experiment?

Make a neat and comprehensive record of your observations and tell what you have learned.

ASSIGNMENT:

1. The study of a filter. What is the use of a filter?

How is a sand filter constructed? To what is the sand filter's effectiveness due?

2. Make a 8" x 9" diagram of a sand filter.
3. Read one: Smith & Jewett; p. 220, par. 88; Caldwell and Eikenberry; p. 163-165.

Lesson VIII. A Visit to the Sanitary Engineer's Exhibit of Sand Filters on the University Campus in Berkeley.

OUTLINE FOR THE EXCURSION.

(Pupils are to obtain the information required to fill the blanks)

SAND FILTRATION:

1. The sand filter has ..... at the bottom, then comes a layer of ....
2. The water should flow slowly through the filter so that ..... the ..... matter will be removed and there will be a chance for the formation of .... which is the home of .....
3. The particles of sand have also a ..... mass around them in which live .... These .... need ..... hence when the water is very foul the water is allowed to cover only a part of the filter beds.
4. Some cities use rapid sand filters in which they place alum and ..... Cleveland and .....are examples.
5. The ..... bacteria destroy ..... matter.
6. A sand filter of the Oakland type removes .....% of the bacteria and other organisms.
7. Freshly cleaned or newly constructed filters have ..... effect on the water. In a freshly cleaned filter the number of bacteria that pass through are more than ....per cc. but before cleaning only .....% per cc.
8. It costs about $..... per ..... gal. lon of water to install and operate a sand filter.
9. Pipes are placed below a filter to ..... off ..... water.

ASSIGNMENT:

1. Color the parts of your diagram (of a filter) prepared in Lesson VII and write an explanation of the operation.
2. Prepare a five minute talk on water filters for the the 7th grade assembly.
3. Compare the death rate from typhoid fever before and after the introduction of filters in Oakland.
4. Refer to California Health Bulletin: Oakland Record.
5. How are water tests made by the company?

Lesson IX. The Sand Filter and Health.

PURPOSE: To help the children to express their knowledge of the filter and to help them see the relation of the filter to health.

CLASS DISCUSSION: Five minute talks upon the sand filter. Pick out the best talks by class vote, and have them given in the 7th grade class.

Discussion of the reports on the relation of the sand filter to the decrease in number of cases of typhoid fever, by means of diagrams or graphs.

ASSIGNMENT:

1. How does the water get into the filter?
2. How does a pump act? What is it?
3. Read: a. Caldwell and Eikenberry: p. 129-30 and p. 147-9.
   b. Smith and Jewett: p. 226-7 and p. 230.

Lesson X. The Lift Pump and Force Pump.

PURPOSE: To help the pupil to understand pumps.

CLASS DEMONSTRATION: The simple lift pump.

1. Fill a U-tube with water; place piston ¾ of the way down. Place stopper in other end—air tight. Pull piston to top of U-tube. Note action of water.
2. Repeat the experiment but this time do not close the end with a stopper.

3. Explain the action of the water in both cases.
4. Try the same experiment with a straight tube.
5. Explain how one drinks soda-water through a straw.

   Look at the diagram of a lift pump and from the knowledge gained in the experiments explain how it works.
6. From the diagram of the force pump tell how it works. How does it differ from the lift-pump? How were these used at the reservoir?

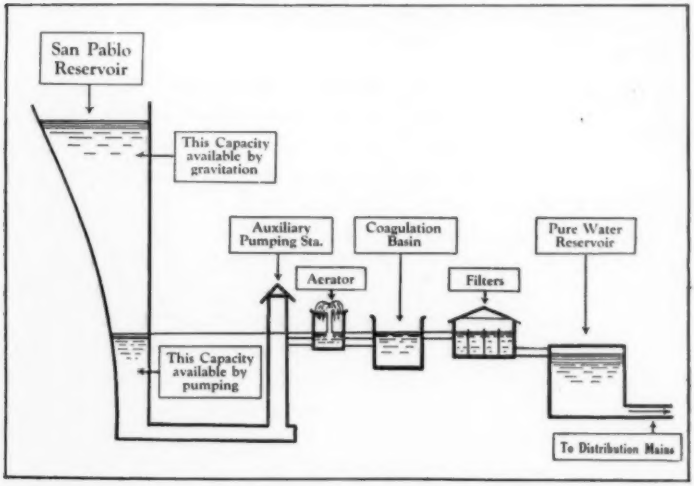


Fig. 2. GRAPHIC ILLUSTRATION OF THE FILTER PLANT AND PURE WATER RESERVOIR, GREAT SAN PABLO LAKE.[1]

ASSIGNMENT:

1. Why does the water rise so high from a fire hose? Why does the water sometimes rush through the faucet and knock the cup out of your hand?
   Read: Caldwell and Eikenberry: p. 133.
2. Why do dams have to be so strong?
   How do men know before a dam is built how much the water will press against it?
   Read one of the first two references given under "Sources of Information."

1 Reproduction from "Collecting and Distributing a Domestic Water Supply." Paul I. Daniels, 1921.

Lesson XI. Study of Water Pressure. (See Fig. 2)

PURPOSE: To help the pupil to appreciate the reasons for building dams of such strong material and what produces the force that occurs at the faucet.

CLASS DISCUSSION: Demonstration of the aquarium and the pipe. The working of some simple problems according to the formula F = Area x depth x weight of 1 unit volume of water.

How is this method of calculation applied to the building of dams? To determining the pressure in pipes?

CLASS DEMONSTRATION. Water pressure varies as the depth.

Material: Short stem thistle tube, rubber tubing, rubber dam, red ink, glass tubing bent in U at one end, meter stick, ringstand, and battery jar.

1. Cover thistle tube cup with rubber dam; fasten glass tube to upright meter stick; attach the rubber tubing to the thistle tube; and then to the U part of the tube on the meter stick. Place a drop of red ink in the tube on the meter stick.

   Fill battery jar with water. Place thistle tube at different depths, say 5, 10, 15, 20 cm. What do you notice about the ink spot?

3. Test the water pressure at a number of depths and in a number of positions. What effect do you notice? What is the effect of doubling the distance from the surface of the water?

   Can you think of the things a construction engineer would have to consider in building a dam? How would the problem of building a dam at Galveston, Texas, differ from that of an irrigation reservoir in the far west?

   Discuss the Arrowrock dam.

ASSIGNMENT: Find out what algae are. Would you think them of benefit to a water system? Why did they put fish in Lake Chabot? Why do they use copper sulphate in some of the Berkeley storage reservoirs? Why are some of the reservoirs covered?

Why are dams built?

Describe a dam that you know and tell why it was built.

Find two illustrations of dams which have been built, but for different purposes.

Have you ever heard of dams breaking? Why? What resulted?

Lesson XII. Trip to Lake Chabot. (See Fig. 3)

OUTLINE FOR THE EXCURSION.

(A copy to be placed in the hands of each pupil)

OBSERVATIONS:

1. Are there any algae on Lake Chabot? Compare this with San Pablo Reservoir.
2. Are there any weeds in the water?
3. Are there any fish in the water?
4. What is the character of the ground of the watershed? (Sand, clay, gravel, rock or loam?)

Fig. 3. A VIEW OF SAN LEANDRO (CHABOT) LAKE. The photograph was taken from an aeroplane at an altitude of 3000 feet. Capacity 5,180 million gallons.

5. What is the character of the vegetation? How much decaying vegetable matter seems to be produced annually? Does this vegetation produce spores or pollen? Would the spores or pollen make the water less safe for drinking and domestic use?

1 Reproduction from "Collecting and Distributing a Domestic Water Supply." Paul I. Daniels, 1921.

6. Is the area inhabited by animals? What kind and how many?
7. Is it occupied by people? How many? How is the sewage cared for?
8. Are any of the lands under cultivation? What fertilizers are used? How would the type of fertilizer affect the water supply?
9. How does Oakland prevent pollution of the watershed? Is there a regular patrol? What powers have the patrol?
10. In what direction is Lake Chabot from Oakland? How does the land slope in this part?
11. Lake Chabot has a drainage area of .....; a depth of .....; a surface area of ..... of water.
12. Lake Chabot supplies Oakland with ..... of water daily. It has a capacity of .....
13. Is there a pumping station for distributing the water to different levels?
14. What is a "Jumbo" system for pumping?
15. Besides San Pablo Reservoir Oakland receives water from the ....., ..., and other wells.
16. Is there an auxiliary pumping system which pumps water out of the Bay in case of fires in West Oakland?

Summary

1. The report of the State Sanitary Engineer on the water analysis of school's samples.
2. San Pablo Reservoir is the chief source of water supply now supplying Albany, Richmond, Emeryville in Contra Costa, and Berkeley, Oakland, and Fruitvale in Alameda County.
3. Lake Chabot and artesian wells supply Oakland, Alameda, San Leandro, and other suburbs.
4. The water front and the downtown sections have an auxiliary water supply which supplies water from the Bay in case of fire.
5. Pumps are used in the old system to raise the water to storage reservoirs in the hilly sections of the city such as in Highland Park, East Oakland, Piedmont, and Claremont.

6. The storage of water in covered reservoirs is practiced in Berkeley to kill the algae; in other places copper sulphate is used; and in others fish.
7. Diseases carried by water have decreased due to the use of storage reservoirs and filtering systems.
8. Dams are used to collect the water in San Pablo and San Leandro creeks.
9. Reservoirs are used to store water and are placed at considerable altitude to secure better pressure throughout the whole system of water supply.

Sources of Information

A. GENERAL.
Oakland Tribune, Annual issue, 1919; 1920.
Pamphlets of the East Bay Water Supply Company.
Pamphlets of the Oakland Chamber of Commerce.
U. S. Geological Survey, Water Paper 298, 1912.
Current magazines, especially the "Sunset."

B. SOURCES OF WATER.
Caldwell & Eikenberry. "General Science," p. 159-160.
Smith and Jewett. "Introduction to Science," p. 186-189.
Hunter and Whitman. "Civic Science in the Home," p. 76-77.
Lake. "General Science," p. 115.
Trafton. "Science of Home and Community."

C. WATER PRESSURE.
Caldwell and Eikenberry. "General Science," p. 133.

D. PUMPS.
Caldwell and Eikenberry. "General Science," p. 129-130.
Smith & Jewett. "Introduction to Science," p. 226-31.
Caldwell, Eikenberry, and Glenn, "Laboratory Problems," p. 79.

E. PURIFICATION OF WATER—FILTERING PLANTS, ETC.
Trafton. "Science of Home and Community," p. 348-349.
Smith & Jewett. "Introduction to Science," p. 220.
Caldwell and Eikenberry. "General Science," p. 163-65.
California and Oakland Health Bulletins on typhoid fever.

F. DAMS.
Smith and Jewett. "Introduction to Science," p. 79-80.
Caldwell and Eikenberry. "General Science," p. 135.
National Geographic Magazine.
Reports of the U. S. Reclamation Bureau.

LESSONS FOR NINTH GRADE PUPILS.
PERIODS 50 MINUTES.

How Incandescent Mantles are Made[1]

C. E. Bliss

While exact data is unavailable, the world's consumption of incandescent mantles may be estimated to approximate 350,000,000 mantles annually. This corresponds to a consumption in the way of the more basic raw materials of, roughly, 7,750,000 pounds of monazite sand, 925,000 pounds of thorium nitrate, 9,000 pounds of cerium nitrate, 2,200,000 pounds of thread, 250,000 pounds of asbestos cord, and 1,500,000 pounds of collodion. The United States consumes annually in the neighborhood of 80,000,000 mantles, while its recently developed and still expanding foreign market requires a production considerably in excess of this figure.

Historically, the rise and development of the incandescent mantle industry may be briefly summarized by the enumeration of certain significant dates. In 1812 in the city of London gas was first successfully used for illumination. It soon came to be recognized that the luminosity depended upon the presence in the flame of small solid particles of carbon, which raised to a high temperature by the heat of combustion, emitted radiations of a wave-length corresponding to the luminous portion of the spectrum. In 1826 Drummond heated a pencil of lime in the oxy-hydrogen flame, giving birth to the still popular limelight. In 1846 Gillard made gas mantles of platinum wire, which shortly thereafter were used in connection with water-gas in both Paris and Philadelphia. 1855 saw the invention of the Bunsen burner, in which part of the air necessary for combustion is entrained by the friction of a jet of gas as it issues from a minute orifice past an air port. In 1881 Lundgren patented a mantle made from a paste of lime, magnesia, and zirconia. This mantle gave an intense white light, but after a few hours crumbled to a powder. About 1883 the Austrian, Dr. Carl Auer Von Welsbach, placed on the market a mantle made by saturating a suitable fabric in a solution of rare-earth oxides, chiefly oxides of lanthanum and zirconium, and then burning away the fabric so as to leave the oxides in a skeleton form. These mantles, however, never attained much commercial use, being mechanically weak and of very moderate candle power. Not until 1891 did Welsbach hit upon the

1 From Commercial America for October 1921.

present thorium-cerium combination; with this discovery the mantle industry at last became firmly established and began to develop with rapidity. In 1903 the first mantle was made from artificial silk. About 1905 began the use of the inverted type of gas burner.

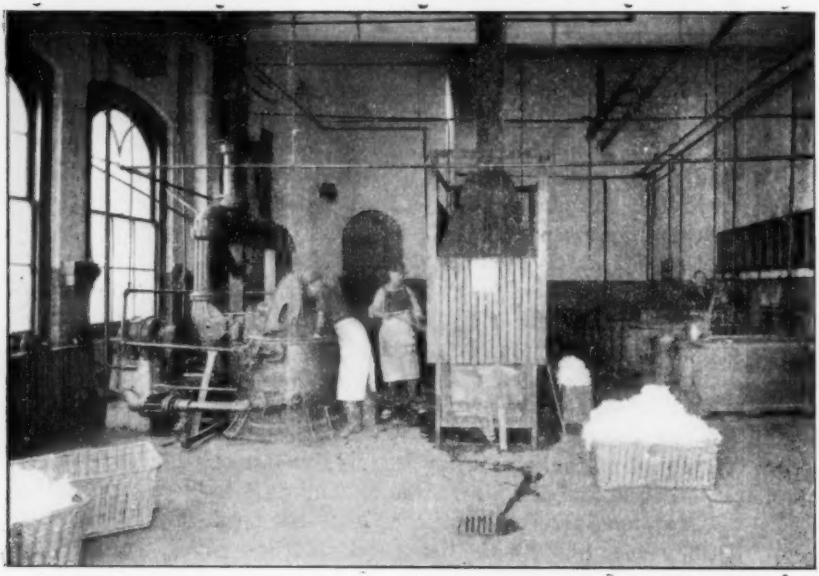
In the manufacture of incandescent mantles the fundamental raw materials are monazite sand, the various mantle yarns, and collodion.

In 1891 the chemical element thorium was so rare as to be almost a curiosity. The principal known sources were the rare minerals, thorite and thorianite, found in very limited quantities in Sweden and Norway. A worldwide search for other sources of supply revealed large deposits of monazite sand, notably in Brazil, in the Carolinas of the United States, and (in 1909) along the seacoast of Travancore, India. To the chemist, monazite sand has a high-intrinsic interest of its own, being, like pitchblende and coal tar, the source of a great variety of remarkable chemical compounds. Monazite varies considerably in composition, but consists essentially of an anhydrous phosphate of the cerium metals (cerium, lanthanum, praeseodymium, neodymium) together with small and varying amounts of yttrium oxide, thorium oxide (1 to 10 per cent), and often small amounts of the oxides of erbium, uranium, zirconium, aluminum, magnesium, calcium, iron, manganese and titanium.

The main product of monazite sand is thorium nitrate. The process of extraction is very long and complicated, requiring from two to three months. The final product to be proper for mantle manufacture must be of a purity much beyond that usually connoted by the term "chemically pure." In 1888 thorium nitrate was quoted at about $500.00 per pound. By 1894 the price had dropped to $216.00 and by 1900 to $3.03. With the outbreak of the war the United States became the principal producer and is still contending for that honor. As by-products of commercial importance monazite yields cerium nitrate, used with thorium nitrate in making mantles, cerium chloride, used for making pyrophoric or sparking metal, didymium nitrate, used for branding trademarks on mantles, and the radioactive substance mesothorium. For this last item there is an active demand, as it is displacing radium for some uses. About 2.5 milligrams of mesothorium are obtained from

a metric ton of monazite sand. The market price is approximately $2,000,000 per ounce.

Mantle yarns are of three kinds, cotton, ramie and artificial silk. Animal fibres like wool or natural silk are entirely unsuitable. Cotton threads should preferably be of high grade long staple cotton. Cotton is used chiefly for upright mantles and for gasoline "rag" mantles, but will not make a high grade inverted mantle of the hardened type. Ramie yarn (known variously as China Grass, wood silk, wood fibre, etc.) is the product of the flax-like ramie plant growing in Southern

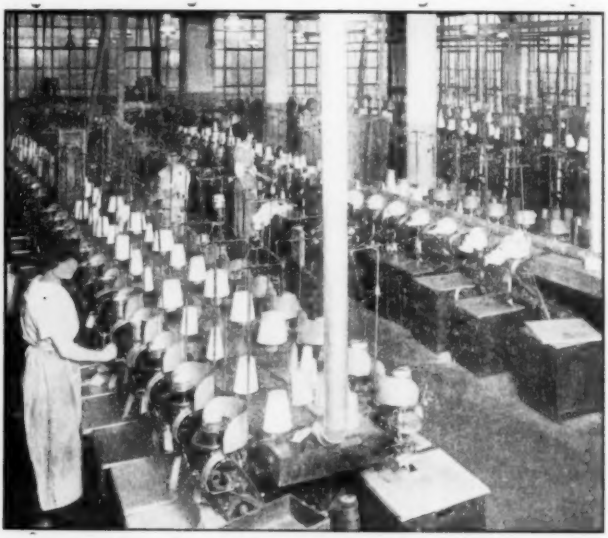


Nitrating cotton for mantle collodion at the plant of the Welsbach Company at Gloucester, New Jersey

China. This yarn much resembles linen, is very strong, and is the standard material for inverted mantles. Artificial silk affords distinctly superior mantles, whatever the type, and doubtless but for the additional cost entailed in manufacture, would today be in exclusive use.

Collodion is a solution of nitrated cotton in alcohol and acetone. It is used to protect the mantle during handling and transportation. Ordinary collodion would shrink on drying and in so doing injure the mantle. The present mantle dips or collodions have been evolved only after years of patient experiment.

The process of manufacture varies as to certain details in different factories. Perhaps the clearest impression can be conveyed by describing the process as carried out by the Welsbach Company of Gloucester, New Jersey. This company was organized by a group of Philadelphia men in 1887 who purchased the patent rights for the United States from Auer Von Welsbach and established a factory on the Delaware river opposite Philadelphia. It has now grown to be very large and is perhaps the finest plant of its kind in the world. It has a capacity of over one million mantles weekly and every modern



Where the knitting of the mantles is done

facility. Besides the mantle factory proper, it has a complete chemical factory for the manufacture of thorium nitrate, by-products of monazite sand, and mantle collodions, modern machine shops for the manufacture of the latest types of burners and lighting fixtures, and numerous testing, experimental and research laboratories.

Knitting and Washing Incandescent Mantles. On machines similar to those used in the knitting of hosiery an underwear the mantle yarn, whether of cotton, ramie, or silk is knit into a continuous webbing or "stocking." As this fabric forms the framework on which the mantle is constructed, much emphasis

is laid upon the selection of proper threads or yarns. Generally speaking these are spun especially for the mantle industry from fibers of the highest grade and purity. For an ordinary upright mantle about nine inches of this fabric is required. For convenience in handling, the day's output from the various knitting machines is sewed into a continuous strip several miles long and taken to the Wash House.

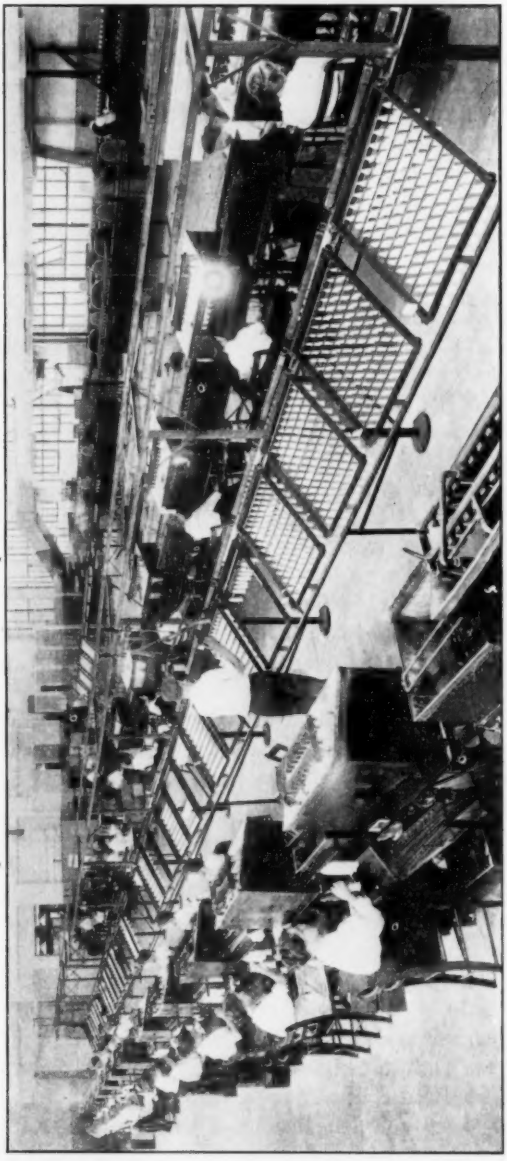
Sewing—Another step in the complicated process of mantle manufacture

It is then subjected to a four day washing process with the object of removing every vestige of grease and mineral matter. Ordinary thread contains from 1 to 2 per cent of "ash" or mineral matter, a contribution from the soil in which the fiber grew. Since mineral impurity in quantities as minute as 0.02 per cent markedly shortens the strength and life of a mantle, the successful mantle manufacturer makes a fetich of purity throughout his manufacturing process. This point is illuminated by observing the pains taken in the Wash House. All

air is washed and filtered. All water is distilled, conveyed in tinlined lead pipes, and used only after analysis has shown the presence of less than five parts per million of impurity. Finally, each lot of webbing is analyzed for "ash" and rejected as unfit for mantle making if the mineral content is over 0.02 per cent. It is claimed that this washed fabric is the purest form of cellulose commercially produced. Indeed, so efficient are the cypress tanks and nickel lined boiling kiers in which the washing is carried out that the results cannot be duplicated in the chemical laboratory with the most immaculate of glassware.

The Saturating Process. After washing, the webbing is dried in an automatic machine under controlled air conditions. It is then weighed out into lots of a convenient size and immersed for fifteen minutes in the "lighting fluid", after which it is passed between a pair of rubber rolls carefully adjusted so as to remove just the right excess of liquor and leave a predetermined amount of fluid in the fabric. While lighting fluids are generally stated to be water solutions of thorium and cerium nitrates in the proportions of 99 to 1, the matter is not really so simple. The Welsbach Company carries always about forty different fluids on its saturating department shelves, each fluid having been worked out as most appropriate for a given kind of mantle. These fluids differ in concentration, in the ratio of thorium to cerium, in acidity or basicity, in content of sulphuric acid, and in addition of most minute quantities of beryllium, aluminum, magnesium and other nitrates, substances which serve to make a mantle both hard and strong. Much skill and experience are required to "make up" a lighting fluid from the nitrates of thorium and cerium. Most manufacturers work out their own formulas which are then carefully guarded as trade secrets.

Drying, Sewing and "Fixing" the Mantles. The saturated webbing is then cut into ninety inch lengths and painstakingly mounted on long maple poles. These poles are suspended from a moving chain which carries them through a drying box in which the temperature is thermostatically controlled and a gentle air current maintained. This drying requires about thirty minutes. The dried strips of fabric are then removed and cut into blanks of suitable lengths for either upright or inverted mantles. If the mantle be of cotton or silk, it is usually "treat-



Hardening the mantles is very important—This view shows the hardening of the "Upright" variety of mantles

ed" by immersing in a bath of ammonia, which converts the thorium and cerium nitrates present to insoluble hydrates.

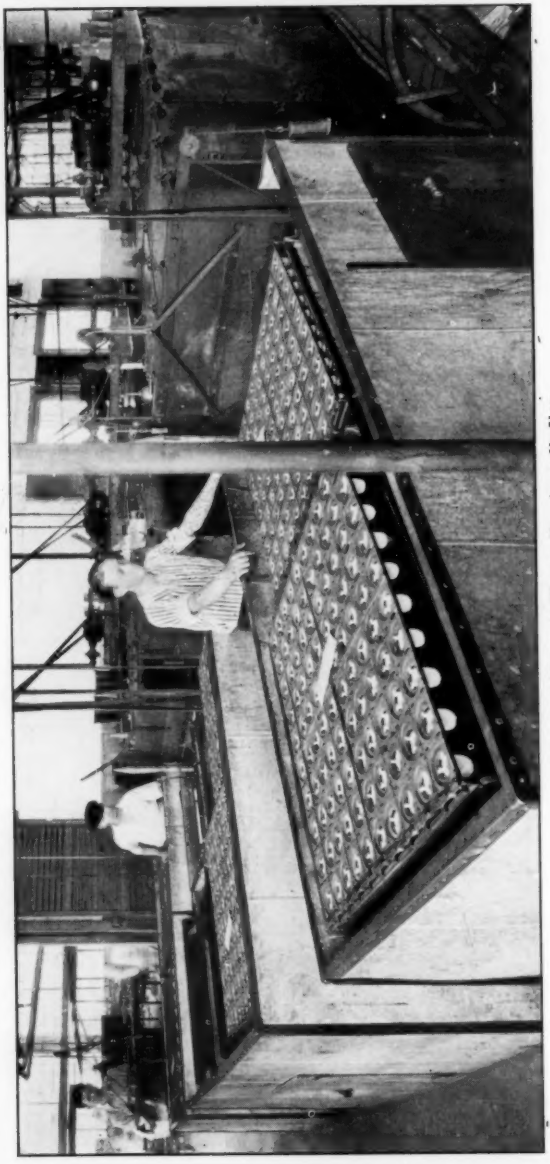
In the sewing room the inverted blanks are shirred on one end with a ramie cord impregnated with lighting fluid. The other end is then fastened to a procelain mantle ring by means of asbestos cord. Finally the point of the mantle is closed by pulling up and tying the previously inserted shirring cord.

The upright mantles are shirred with an asbestos cord, which is then tied in such a way as to gather the mantle at the top and leave a supporting loop.

A strengthening solution, known as "fix" or "head solution" is then painted on the mantle at the point of support. These fixes are usually dyed solutions containing water, alcohol, and various chemical salts. Each manufacturer has his own secret formulas, developed after years of experience. Each fiber, and each type of mantle requires its own individual fixing fluid.

How the Branding and Hardening is Done. Various trade marks may be applied by means of a rubber stamp and a dyed solution of didymium nitrate. These brands are often invisible except when the mantle is burning.

The mantle is now ready for the hardening room. The hardening operation, at least for purposes of description, is three-fold, consisting of modelling, burning out and hardening proper. In the modelling the mantle is pulled over a suitable wooden model so as to remove all wrinkles and stretch the fabric into a suitable shape. In the burning out the mantle is passed through a gas flame in such a way as to become ignited at the top, whereupon it is moved along and allowed to blaze until all the original thread is entirely consumed, only a skeleton of pure chemical oxides remaining. This skeleton is about one-half the length and diameter of the unburned mantle, is extremely soft and flexible, and is without any definite shape. The miracle is that it holds together at all. In the hardening proper, upright mantles are put over a series of gas blow torches so arranged that the hardening machines operator can manipulate the flames by means of gas and air levers at the same time that she manipulates the mantles up and down on the burners. The mantle is thus blown out and shaped by the pressure of the flame, and then sintered or hardened into permanent shape by increasing the flame temperature. The skill



Dipping "Inverted" mantles in collodion

required by the operator is not incomparable to that displayed by the glass blower.

While inverted mantles are generally hardened in much the same way as upright, the Welsbach Company uses a patented machine which is almost entirely automatic in operation and which makes use of crucibles for molding the mantles into shape. This machine gives a uniform product of a quality unattainable with the old method.

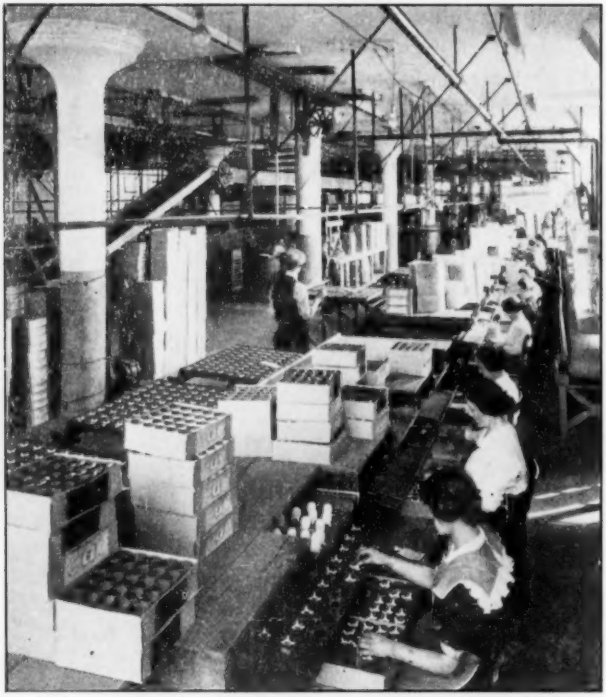
The temperature of the hardening flame reaches the melting point of platinum, and therefore most hardening machines exhibit a scrupulous selection of heat resisting materials, such as nichrome, nickel, monel metal, phosphor bronze, and clay refractories. To the mantle manufacturer the hardening process is one of never failing interest. So perfectly does the thoria, molecule by molecule, substitute for the cellulose molecules, that after burning away the thread its minutest fiber is still visible under the microscope. As might be inferred, it is found that the strength and other characteristics of the resulting ash depends in a very direct way upon the nature of the original thread.

The Importance of Collodionizing. The hardened mantle is much too fragile to stand transportation without protection of some sort. It is said that in the early days mantles were delivered from hardening machine to consumer by messenger on tip-toe. Next the mantle was immersed in melted paraffn, and the paraffin allowed to congeal. The customer received a block of paraffin and had only to melt it to discover his purchase. Today mantles are dipped, ten or one hundred at a time, into a collodion solution. Upon drying, the solvents quickly evaporate, leaving a protecting film. This film burns away quickly and entirely upon application of a flame. While a proper collodion protects against injury due to transportation, the mantle structure will almost surely be injured if handled. This injury, most unfortunately, does not become apparent until the collodion is burned off. Mantles should never be handled save by the supporting ring, carrier, or supporting loop.

Trimming and Packing. After being collodionized, it is necessary in the case of upright mantles to cut to length by trimming away the uneven skirt at the bottom. The mantles

are finally inspected for defects of various kinds and packed for shipment.

Mantles sold in the unhardened state are known in the trade as rag or "unbreakable" mantles. Mantles for use with gasoline lamps, as well as certain small mantles for use with gas, are preferably of this type. In this case the hardening opera-



Inspecting and packing mantles at the Welsbach factory

tions are performed by the consumer. Also many standard size inverted mantles of this type are marketed, although their use is frowned upon by the reputable manufacturer as giving very doubtful and unreliable service because of the difficulty of properly shaping and hardening. Their first cost is low, but they give very inefficient service.

TESTING. Appearance is almost no criterion of the quality of a mantle or the service it will render. Therefore the conscientious manufacturer protects his customer by testing daily

a large number of mantles taken at random from the packing department. In the bumping test, mantles, after the collodion is burned off, are mounted on a machine and subjected to the shock of a ⅜ inch drop. A high grade mantle will withstand 500 such bumps without breaking. In the tensile strength test for upright mantles, the mantle is suitably gripped by skirt and asbestos loop and pulled until it parts. The machine registers the required force. A good cotton or ramie mantle withstands a force of 25 grams, a silk mantle 50 grams. In the shrinkage test, a mantle is burned for 24 hours and the diminution in size noted. A good cotton or ramie mantle will show almost no shrinkage. A silk mantle will show no shrinkage in 1,000 hours of burning. In the endurance test, mantles are burned for 500 or 1,000 hours and any defects noted. In the candle power test, the light giving power is read on a photometer. Curiously, the eye is not a safe as to candle power, a white light of low illuminating power appearing brighter than a yellow light of much greater candle power. It is well known that a mantle very light in weight, the so-called "flash mantle", gives great candle power, but at the expense of strength and durability. Therefore, the manufacture does not place undue credence on any one test, but rather aspires to a high average in all so as to obtain a well rounded and reliable product.

The Grinding of Eyeglass Lenses [1]

R. H. Cannon

The manufacture of optical lenses involves the use of abrasives in nearly every operation from the time the glass is moulded until it is ready for use. A description of the preparation of an ordinary eyeglass lens will illustrate the various abrasive processes used.

Removing of Surface Bubbles

The lens blank, as it comes from the mould, sometimes contains upon its surface tiny air bubbles, in addition to the burrs on its edges. The first grinding operation consists of removing these bubbles by the use of an ordinary floor grinding stand equipped with a silicon carbide abrasive wheel. This is

1 Courtesy of The Norton Company, Worcester, Mass.

the only grinding operation employing silicon carbide abrasives, all other operations being performed with aluminous abrasives.

SURFACING

The amount of finishing done on the lenses by the manufacturer depends upon the specifications furnished by the retailer. Sometimes the manufacturer finishes both sides of the lens, sometimes only one side, and sometimes leaves both sides unfinished. The lenses are left oversize in thickness, unless finished on both sides, and are always oversize in diameter. The retail optician cuts, finishes, and polishes them to the size and shape desired. The lenses are surfaced by the use of aluminous abrasive grain and polished with rouge, the work being done on either individual hand-operated or automatic machines.

Surfacing lens blanks to the proper curvature with loose alundum grain

HAND SURFACING MACHINE

The size of abrasive grain used and the number of operations performed before the final polishing vary in the different shops. Here is shown an individual hand-operated surfacing machine as used by many opticians.

The hand-operated machine consists essentially of a large metallic bowl in the bottom of which, mounted on a spindle, is a cast-iron hemispherical lap. The lens is surfaced by being attached to an iron block and held against the revolving lap of the proper curvature, motion being given the lens by means of a vertical post attached to a movable horizontal lever arm.

Preparatory to grinding, the lens blank is cemented to its cast-iron block generally by means of a mixture of tar, resin, and plaster of paris. The mixture is warmed, so that it flows freely; and the blank is pressed in place, care being taken that the lens rests evenly and, therefore, is ground to the same thickness all over. A lap of the proper curvature is selected, placed on the spindle, and revolved at about 750 r. p. m. By means of the vertical post attached to the horizontal handle, the lens blank is held against the lap, which is covered with a mixture of aluminous abrasive grain and water. During the grinding, the lens is continuously moved up and down the surface of the lap.

The consistency of the mixture of abrasive grain and water is very important. If it is too dry, it will become spread over the lap unevenly, exposing bare spots on the lap and causing scratches. If too much water is added, the abrasive particles will flow too easily and break up the film which is so necessary for good work.

The first surfacing operation is made using No 80 or 90 grain, the second using No. 150, 180 or 200, and the third with finishing flour, which in some cases is the product of the breaking down of the coarser sizes previously used. This broken-up abrasive is sized by the flotation method and the finest of it used for the final smoothing. Some of the large optical manufacturers prepare it after they have used the abrasive on the roughing operations and sell the excess over their requirements to the retailers.

After the operation with finishing flour, a felt pad is fastened onto the cast-iron lap, and the lenses are polished with rouge on the same kind of machine.

AUTOMATIC SURFACING MACHINES

When large numbers of lenses of the same curvature are surfaced by the manufacture, they are placed in multiple on large blocks and surfaced on a multiple-spindle machine. Sometimes as many as 100 lenses can be fastened on one block and ground on one lap. The diameter of the block and lap depends, of course, on the radius of curvature of the lenses, and hence the number of lenses, which can be placed on one block is limited. The smaller the radius of curvature, the fewer can be done on one block.

A battery of automatic multiple-spindle machines

Above is illustrated a battery of automatic multiple-spindle machines. The lenses are cemented to the block (second machine in figure), which is mounted at the top of a vertical spindle and can be rotated. A lap having the proper curvature is selected (the workman in the figure is shown testing a lap for curvature by means of a template) and attached eccentrically to the overhead vertical spindle. On rotating, due

to the eccentric attachment, different parts of the lap come in successive contact with the lenses, thus producing lenses of more uniform thickness.

This method of spinning the lenses on the lap is correct for plain spherical lenses, whether concave or convex; but, when the lenses are cylindrical, that is, with one meridian straight and the one at right angles to it curved, or when they are toric, that is, with these two meridians of different radii of curvature, a different method is necessary. In these cases the lens must not spin on the block, and special machines are used for the many combinations required. In one of them, for instance, the lap revolves while the lens is moved back and forth across it at right angles.

After surfacing, the lenses are polished with rouge, then centered and cut to the proper size and shape with a diamond tool. This process leaves the edges rather rough and necessitates another grinding operation—that of edging.

EDGING

Lens edging is done on a special automatic machine. The grinding wheel runs at about 1,200 s. f. p. m. and reciprocates slowly from side to side, so that its face will be worn evenly.

The shape of the lens is controlled entirely by the form of a pattern which acts like a cam and touches a contact plate. The length of the lens is obtained from setting an index dial at the proper figure.

The lenses are carefully centered in a centering attachment and then placed in a lens holder attached to the machine. If more than one lens is edged at the same time, rubber pads are placed between the lenses. The automatic machine produces lenses with straight edges only. If they are required to be bevelled, this is done offhand after the automatic operation. The operator holds the lens between his thumb and finger and lets it spin against the wheel, an operation requiring a great deal of skill and experience to obtain an even bevel.

All that remains to be done after the edging and bevelling is to drill the lenses with a diamond drill and assemble them in the frames.

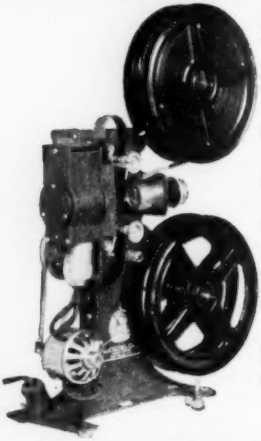
Vitalize Science Teaching with Motion Pictures

No Fireproof Booth—No License Required

An Ideal Safety Machine

Now Available

Through arrangements made with the United Projector and Film Corporation we are now able to offer to schools a portable safety motion picture projector for use with non-inflammable films. Some of its good feature are:



1. No danger, no operator's license, no booth needed.
2. Machine connects to any electric light socket in any school room.
3. It gives a brilliant light. Uses 165 watt lamp.
4. Flexibility of use; 10 ft. to 100 ft. room. Picture up to 14 ft. diameter.
5. Film is motor driven with automatic release.
6. Motor rewinds film.
7. Both 500 ft. and 1000 ft. reels can be used.
8. Speed under control of rheostat.
9. Every machine inspected by Underwriter's Laboratory.

Price of Projector Complete $250.

Rental of the Basic Course in General Science, consisting of 64 reels, described in "General Science Visualized" is $60. A 165 page book describing available educational films is given to every purchaser of the machine.

It is the best machine for home, school, church and industrial use. It gives the most brilliant illumination of any portable projector.

Send us your orders at once and we assure you prompt service. Machine sent on trial if desired.

General Science Quarterly: SALEM MASS.

Water Power of the World

Forty per cent of the developed water power of the world is in the United States, where water wheels having a capacity of 9,243,000 horsepower have been installed, according to a recent statement of the United States Geological Survey, Department of the Interior. The leading States in developed water power are New York, with 1,300,000 horsepower, and California, with 1,111,000. These State totals compare favorably with those for some of the most progressive countries in waterpower development in Europe, where France leads with 1,400,000 horsepower, Norway has 1,350,000 horsepower, Sweden 1,200,000 horsepower, and Switzerland 1,070,000 horsepower. The largest percentage of power has been developed in the New England States, where the capacity of the water wheels installed is 1,381,000 horsepower and the estimated potential power at low water without storage is 868,000 horsepower. In the Pacific Coast States—Washington, Oregon, and California—the capacity of water wheels installed is 1,893,000 horsepower and potential power at low water without storage is 11,500,000 horsepower. The largest water-power development in the world is at Niagara Falls, where the plants in operation have a capacity of 870,000 horsepower, of which 385,500 horsepower is on the United States side. The capacity of the plants at Niagara is being increased by 114,500 horsepower in the United States and 300,000 horsepower in Canada. Other large plants are one of 170,000 horsepower on the Mississippi at Keokuk, Iowa, from which power is transmitted to St. Louis, and two plants aggregating 268,500 horsepower on St. Maurice River in Canada, from which power is transmitted to Montreal, Quebec, and other cities. Canada ranks next to the United States in water-power development, with 2,418,000 horsepower, or over 10 per cent of the world's total.

Europe has one-third of the developed water power in the world. Two plants at Rjukan, in Norway, have a total capacity of 239,000 horsepower, and at Trollhattan Falls the Swedish Government has installed a plant of 155,000 horsepower. At Lake Fully, in Switzerland, the remarkably high head of 5,413 feet is utilized. France, Italy, Germany, Norway, Sweden, and Switzerland have each developed more than 1,000,000 horsepower.

In Asia, Japan, with 1,000,000 horsepower, and India, with only 150,000 horsepower, are the foremost countries in water-power development.

New Zealand has developed only 45,000 horsepower but is rapidly increasing this amount. Australia has practically no developed water power. The island of Java has 56,000 horsepower developed or to be developed by plants under construction. Africa possesses only 11,000 horsepower of developed water power.

The total potential water power of the world is estimated at 439 million horsepower at low water, of which 62 million horsepower is in North America and 28 million in the United States. Africa is richest in undeveloped water power, with 190 million horsepower; Asia has 71 million horsepower, South America 54 million horsepower, and Europe 45 million horsepower.

The World Atlas of Commercial Geology, Part II, Water Power of the World, which has just been published by the United States Geological Survey, summarizes all present knowledge of that subject, mentions briefly some of the world's largest water-power developments, and gives estimates by countries and by continents of the developed and undeveloped water power. It includes 37 pages of text and 10 maps and is sold for $1 a copy.

A Motion Picture Course in General Science

Under the supervision of Mr. J. H. Wilson, former Head of Visual Instruction of the Detroit Public Schools, a course in general science illustrated by films has been arranged. These films are on non-inflammable stock and are for use with a safety projector. Teachers can use these without fireproof booth and without an operator's license.

This is the first attempt, as far as we know, to select and organize suitable films to assist the teaching of general science. Sixty-four 500-ft. reels are listed as a basic course on the following topics: evolution, air, water, foods, health, pests, games, public health, transportation, mining, farming, general industries, textiles, forestry, nature study, birds and animals. The basic films on evolution are: "Birth of the Earth," "Origin of Coal" and "How Life Begins." The Course also includes: The wonderful Bray Pictographs; How we hear; How we breathe; Thru life's windows; Formation of dew; and many others.

The 64 basic films are all discussed in "General Science Visualized," a book of 96 pages written by Mr. Wilson. First is given the lesson purpose, then follows an outline of the facts which are to be illustrated by the picture. These outlines make it possible to discuss with profit with the pupils, the subject before the film is shown and to clinch the important lessons of the picture by subsequent class discussions. From one to two hundred supplementary films are classified on the same subject matter and listed parallel to the basic films. A list of helpful references for study is given for each of the different subjects.

"The basic course deals with the sources and more common combinations of matter. It treats of the primary laws of life and their applications. Its entire purpose is to present common elements and experiences as an aid to a more intelligent use of scientific knowledge in the work-a-day world and to more thoroughly prepare the student for scientific study later on."

The United Projector and Film Corporation has control of this course and they also offer a complete series in Physics, prepared by Prof. W. D. Henderson. "Experimental Physics Illustrated by Moving Pictures" is the title of a pamphlet describing this course.

WHAT TO MAKE

A water clock. Pop. Sci. Mo. p. 88. Sept. 1921.
A vest pocket blow torch. Pop. Sci. Mo. p. 92. Sept. 1921.
A weather glass. Pop. Sci. Mo. p. 106. Sept. 1921.
A simple Daniell Cell. Pop. Sci. Mo. p. 86. Aug. 1921.
A chemical balance. Sci. and Inv. p. 340. Aug. 1921.
A toy motor. Sci. and Inv. p. 343. Aug. 1921.
Electric toaster. Pop. Mech. p. 303. Aug. 1921.
Bicycle Horn. Pop. Mech. p. 304. Aug. 1921.
An Ellipsograph. Pop. Mech. p. 455. Sept. 1921.
A simple Ammeter. Pop. Mech. p. 466. Sept. 1921.
A Static Machine. Pop. Sci. Mo. p. 87. Nov. 1921.
A Synchronous Motor. Pop. Sci. Mo. p. 97. Feb. 1922.
Telegraph Sounder. Ill. World. p. 784 and 792. Jan. 1922.

Free Scholarship for High School Student

A four years' university scholarship is offered high school students to encourage them in the study of highway economics. The scholarship is given by Harvey S. Firestone, Akron, Ohio, a member of the Highway and Highway Transport Education Committee, for the best essay written on the subject: "How Good Roads Are Developing My Community," submitted in a national essay contest. Essays, according to rule announced today, are not to exceed 700 words in length, and must be in the hands of a high school teacher or principal not later than May 1. All students of high school grade, including both public and private schools, are eligible to complete.

Aims of the contest, according to the committee, are the stimulation of thought, discussion and study of the problems of highway transport, highway economics and highway engineering, as a corollary to a course in these subjects now being prepared for the committee by the leading economists and engineers of the country for use in colleges and universities.

The contest last year was won by Miss Garland Johnson, a pupil in the Bridgeport, West Virginia, high school. Miss Johnson, upon her graduation, will attend one of the leading women's' colleges, all tuition and reasonable expenses being defrayed by the donor of the scholarship. The first scholarship offered was awarded Miss Katharine F. Butterfield, Weiser, Idaho, who is now in her second year in college under the terms of the scholarship. The scholarship is valued at not less than $4,000.

Complete rules of the contest, a bibliography, suggestions and other information may be had upon application to the Highway and Highway Transport Education Committee, Willard Building, Washington, D. C.

Book Reviews

The Everyday Health Series.—Book 1. *Building Health Habits*—280 pages—illustrated.

Book 2. Keeping the Body in Health—311 pages—illustrated.—M. V. O'Shea and J. H. Kellogg—The Macmillan Company.

This new 1921 edition of the Everyday Health Series presents the various health topics in a pleasing style, particularly interesting to children. The convenient size and attractive pictures also make a strong appeal to young pupils. Book One deals with health habits, some disease carriers and safety first. Book Two explains more about how the various body processes are carried on, and encourages pupils to apply health principles in everyday life. Both books end with a helpful glossary. Study and even a careful reading of these books cannot fail to produce a lasting influence for better health.

Nostrums and Quackery, Volume II—Arthur J. Cramp M. D.—832 pages—Numerous illustrations—$2.00—The American Medical Association, Chicago.

In 1911, volume one of Nostrums and Quackery was published. A few years later this was republished with an additional 200 pages. The new material which has been accumulating since then is now available in book form. Volume two does not repeat matter given in volume one. Both volume one and volume two ought to be available in every school library for reference. Good health is a vital topic in general science as well as in hygiene, and every teacher should procure a personal copy of this work if it cannot be obtained by the school. Students will eagerly read this book and give good reports upon

Two Unique Devices

WHICH MAKE VISIBLE

Molecular Phenomena

to

GENERAL SCIENCE STUDENTS

Knipp's Mercury Tube

F2215
$3.75

As described in the May, 1917, number of School Science and Mathematics and demonstrated by Prof. Chas. T. Knipp before the annual meeting of the Illinois Academy of Science at Galesburg.

The pithball is lifted by the pressure of the boiling mercury vapor and shot violently into the upper bulb, or it may be held suspended in empty space by properly controlling the heat, demonstrating (1) lowering of boiling point of mercury under diminished pressure, (2) equilibrium point in process of evaporation, (3) pressure of a vapor due to bombardment of molecules, (4) increase of pressure with increase of molecular velocity, (5) phosphorescence of mercury in the dark and (6) mercury "hammer" when tube is quickly inverted.

Send for Bulletin 18M.

Stoekle's Molecular Apparatus

F2216
$2.50

This new molecular demonstration apparatus was designed by E. R. Stoekle of the Physical Laboratory of the Cutler-Hammer Manufacturing Company as the result of an accidental discovery in the Laboratory. It consists of a glass tube ten inches long and one inch in diameter containing a small amount of mercury, on the surface of which floats a small quantity of particles of crushed blue glass. The tube has been exhausted to a fairly high vacuum and sealed.

When heated, the particles of mercury carry the glass with them into the space above, where they move about in a manner similar to the motions of molecules.

Send for Bulletin 153M

CENTRAL SCIENTIFIC COMPANY

460 East Ohio Street

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nostrums to the class. From the scanty treatment of this subject in our text-books, it would appear that publishers of school texts fear the power of these strongly intrenched fraudulent concerns. But thanks to the Propaganda Department of the American Medical Association, we can at very small expense provide material for education on this subject which will yield practical results in the homes of our students.

General Science Instruction In the Grades.—Hanor A. Webb—105 pages—published by the Peabody College for Teachers, Nashville, Tennessee.

This is a report: first, of a painstaking, quantitative analysis of the eighteen general science texts in print in 1919 and second, of the reaction of seventh, eighth, and ninth grade children to science. The ten texts which have entered the field since this study was made might possibly give somewhat different results as far as content is concerned; but in the main the conclusions drawn from the study from the eighteen books reported would stand. Attention is called to the subject matter, acceptability and size of topics, distribution and correlation of sciences.

A summary of the composition based on special science topics follows:

Science	Number of Texts in Which the Science Ranks							
	1st	2d	3d	4th	5th	6th	7th	8th
Physics	14	1	2	1	—	—	—	—
Physiography	2	6	2	4	2	2	—	—
Biology	—	7	7	1	—	2	1	—
Physiology	2	3	2	2	6	1	1	1
Chemistry	—	1	4	4	3	4	2	—
Household Art	—	—	1	2	3	6	3	3
Astronomy	—	—	—	3	4	1	6	4
Miscellaneous	—	—	—	1	—	2	5	10

From a very elaborate study of the reaction of children to the various special science topics commonly included in a general science course, the author reaches this conclusion—that physiology and physiography are appropriate for the sixth grade; biology and physics can be assimilated in the seventh grade; physics is best in the eighth grade; and chemical topics are the most difficult for grade children.

Education students interested in a study of general science will find many valuable suggestions in this pamphlet.

The Riddle of the Rhine—Major Victor Lefebure—279 pages—W. Collins Sons and Company, Limited, London.

In this we are given a forceful word picture of the four-hundred million dollar organic chemical industry known as the Interessen Gemenschaft whose establishments are located, with one exception, along the banks of the Rhine. The German dye monopoly in prewar times gave the Germans a headstart in chemical warfare because this peace time industry could in an instant make war products rather than peace products.

A reading of this book will leave no doubt in your minds of the importance of preventing the Germans from having a world monopoly of the dye industry in the future. Much information given in this book will be found of value in your science teaching.

Physics in Everyday Life—William D. Henderson—566—pages—599 illustrations—Lyons and Carnahan.

The organization of this text is that of the usual high school text. It differs however, in its treatment; as the author states in the preface, the order of procedure is (a) interesting introductory topics,

ANOTHER NEW SCIENCE BOOK

Civic Science in the Community

By GEORGE W. HUNTER, *Ph. D., Professor of Biology, Knox College, Galesburg, Illinois. Formerly Head of Department of Biology, DeWitt Clinton High School, New York, and* WALTER G. WHITMAN, *A. M., Editor, General Science Quarterly; Physical Science Department, State Normal School, Salem, Mass.*

AN introductory Science book suited for both boys and girls from twelve to fifteen years of age. In it the topics of the community are treated in a way which will appeal to the pupil and spur him on to work for ideal conditions in his environment. Practical suggestions are given for improving conditions in his community. Better citizenship is the ultimate aim.

Each chapter is introduced by a list of problems setting forth what is to be accomplished and this is followed by a list of projects which may be worked out by indiviuals or groups. Laboratory experiments and demonstrations are outlined where needed in the text and each chapter ends with a helpful bibliography for both students and teachers. A feature not found in other General Science texts is the inclusion of numerous score cards which serve to link the school work with real life outside.

In accordance with the recommendation of the bulletin "Reorganization of Science in the Secondary Schools," this book includes Hygiene. In all respects the work is in full accord with the present trend of pedagogical thought.

The Contents of this book are: Part I. ADVANTAGES OFFERED BY THE COMMUNITY. The Ideal Community; How the Community Came into Existence; Natural Resources of the Community. Part II. WEATHER AND CLIMATIC CONDITIONS. The Effect of Climate on Community Life; Weather and the Weather Bureau. Part III. WATER AND ITS PLACE IN THE LIFE OF THE COMMUNITY. The Relation of Water to Power; The Relation of Water to Food Production; The Relation of Water Supply to Forests; The Community Water Supply. Part IV. HOW THE COMMUNITY CARES FOR ITS CITIZENS. Organization of a City Government; How the Community Provides for Pure Food; The Pure Food and Drug Act and How It Operates; How Diseases Are Spread and How to Fight Them; The Relation of Insects to Disease; Disposal of Wastes; Street Lighting; How the Community Safeguards Life and Property; Advantages for Education and Recreation. Part V. TRANSPORTATION AND COMMUNICATION. Good Roads; Transportation by Water; Development of Land Transportation; The Automobile and Gasoline Engine; Transportation through the Air; Means of Communication. Part VI. HOW LIFE ON THE EARTH HAS IMPROVED. How Plants and Animals Have Been Improved; How the Human Race Has Progressed.

ALREADY PUBLISHED

HUNTER & WHITMAN'S CIVIC SCIENCE IN THE HOME

AMERICAN BOOK COMPANY

New York Cincinnati Chicago Boston Atlanta

(b) discussion of laws and principles, (c) practical illustrations." A long list of questions and problems follows each chapter. These lists are of particular value in helping the pupil review in preparation for college entrance examinations. The book will appeal to those teachers who wish to stress every-day science and yet must prepare students for college entrance.

A Laboratory Manual for Comparative Vertebrate Anatomy—L. H. Hyman—380 pages—69 illustrations—$2.70 postpaid. University of Chicago press.

This book supplies a special need of the pre-medical course and will be found of much value in other college classes. A certain amount of working text material is essential during the laboratory disection. Ordinarily one must consult reference books for this material but in this manual will be found not only the laboratory directions for disections of various systems but also brief generalized accounts of the development and evolution of these systems. With this manual it is believed that the student will learn the anatomy of an animal by the shortest and easiest route.

The table of contents comprises these general subjects: General Considerations of Animal Form; The Phylum Chordata; General Study of Typical Chordates; General Features of Chordate Development; The Comparative Anatomy of the Integument and the Exoskeleton; The Endoskeleton: the Comparative Anatomy of the Vertebral Column; The Endoskeleton: The Comparative Anatomy of the Girdles, the Sternum, and the Paired Appendages; The Endoskeleton: The Comparative Anatomy of the Skull and the Visceral Skeleton; The Comparative Anatomy of the Muscular System; The Comparative Anatomy of the Coelom, Digestive, and Respiratory Systems; The Comparative Anatomy of the Circulatory System; The Comparative Anatomy of the Urogenital System; The Comparative Anatomy of the Nervous System and the Sense Organs.

Vision Chart for Schools—A chart 33" by 12" for testing vision—10c—. Eyesight Conservation Council, Times Building, New York City. When you send for your chart ask for other eyesight literature of interest to teachers.

Science Articles in Current Periodicals

AERONAUTICS

The fourth airplane record for America. Lit. Dig. 72:2:49, Jan. 14, 1922.

Pony blimps for fighting forest fires. W. Hutchinson. Am. For. 27:618. Oct. 1921.

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The foremost intellectual achievement of Ancient America. Ill. S. G. Morley. Nat. Geog. Mag. 61:109-130. Feb. 1922.

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Mountain lion. Ocelots and lynxes. Ill. R. W. Shufeldt. Am. For. 27:629. Oct. 1921.

ASTRONOMY

Mars as a living planet. G. H. Hamilton. Sci. Mo. 13:376. Oct. 1921.

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Buying a second-hand car. Edna Purdy. Sci. and Inv. 9:902. Feb. 1922.

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The island of Bermuda. Ill. W. H. Taft. Nat'l Geog. 61:1-26. Jan. 1922.

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Impending problems of eugenics. Irving Fisher. Sci. Mo. 13: 214. Sept. 1921.

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Delaware River bridge between Philadelphia and Camden. Ill. Ralph Modjeski. Jour. Fr. Inst. 193:1-14. Jan. 1922.

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How chocolate is made. Com'l Amer. 18:8:35. Feb. 1922.

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The high cost of electric energy. Rev. of Rev. 65:|213. Feb. 1922.

FIRE

Our dangerous school houses. Amer. City. 26:14-15. Jan. 1922.

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FISH

Certain citizens of the warm seas. Ill. L. L. Mowbray Nat'l. Geog. Mag. 61:27-62. Jan. 1922.

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Can we live 100 years? John B. Huber. Pop. Sci. Mo. 100:1: 30. Jan. 1922.
Weak eyes and high prices. Lit. Dig. 72:7:27. Feb. 18, 1922.
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Ideal section of Lincoln Highway. Pop. Sci. Mo. 100:1:54. Jan. 1922.

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American City. The Tribune Building, N. Y. C. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

American Forestry. Washington, D. C. Monthly. 40c a copy, $4.00 a year. Splendid pictures for plant and tree study.

Commercial America. Phila. Com'l Museum, Phila., Pa., $2.00 a year. Ill. Commercial production. New Inventions. Will interest Commercial geography and science teachers.

Current Opinion. 65 W. 36 St., N. Y. Monthly. 35c a copy, $4.00 a year. Has a regular department "Science and Discovery" containing articles of popular interest, adapted to pupil or teachers.

The Educational Screen—5200 Harper Avenue, Chicago. Monthly 15c copy, $1.00 a year. Discusses the use of movies in our schools; gives brief descriptions of educational films and lists theatrical films which are suitable for children. The journal is entirely educational having no commercial affiliations.

Experimental Science. 1311 G St. Washington, D. C. Monthly. 15c a copy, $1.50 a year. An interesting boys' magazine. Strong on wireless.

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy, $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Geographical Review. Broadway at 156th St., N. Y. $1.25 a copy $5.00 a year. Devoted to scientific geography. Original maps and pictures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Illustrated World. Drexel Ave. and 58th St., Chicago. Monthly. 25c a copy, $3.00 a year. Many short articles on applications of science and mechanics. Popular in style and attractive to elementary and high school pupils.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 1121 Cathedral St., Baltimore. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., N. Y. Weekly. 10c a copy. $4.00 a year. Has a department "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

Journal of Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high grade pictures. Articles are of interest to general reader, pupils and teachers, as well as to geographers.

SCIENCE

Review of year 1921. Sci. Am. 126:20. Jan. 1922.

SCIENCE RESEARCH

Succeeding in scientific research. R. F. Yates. Sci. Am. 123: 236. Oct. 1, 1921.

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Composite portrait of America's great scientists. Pop. Sci. Mo. 99:5:52. Nov. 1921.

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Sewage: the price of civilization. Ill. H. A. Mount. Sci. Am. 126:125. Feb. 1922.

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Overhauling the human mechanism. W. A. McGarry. Sci. Am. 126:94. Feb. 1922.

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Trees with bright autumn foliage. Ill. F. L. Mulford. Am. For. 27:648. Oct. 1921.

Hard Pines of the Northeast. Ill. J. S. Illick. Am. For. 27: 487-496. Aug. 1921.

Evergreens. Ill. F. L. Mulford. Am. For. 27:497. Aug. 1921.

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Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles well illustrated. Appeals strongly to elementary pupils. Suggest many construction projects.

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Review of Reviews. 30 Irving Place, N. Y., N. Y. Monthly. 35c a copy, $4.00 a year. An illustrated monthly covering world affairs. Contains many good articles bearing on science, suitable for class reports.

Safety Engineering. 80 Maiden Lane, New York. Monthly. $3.00 a year. 25c a copy. A journal devoted to conservation of life and property and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Scientific American. Woolworth Building, N. Y. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated and is particularly valuable to high school science pupils and teachers.

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Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles as a rule are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

The Screen. 114 West 44th St., N. Y. Monthly. 10c a copy. $1.00 a year. Articles on use of motion pictures and descriptions of films.

Transactions of the Illuminating Engineering Society. 29 W. 39th St. N. Y. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.

Visual Education. 806 W. Wash. Blvd., Chicago. Monthly. 15c a copy. $1.00 a year. Discusses films, film making and the various visual aids for school use.

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